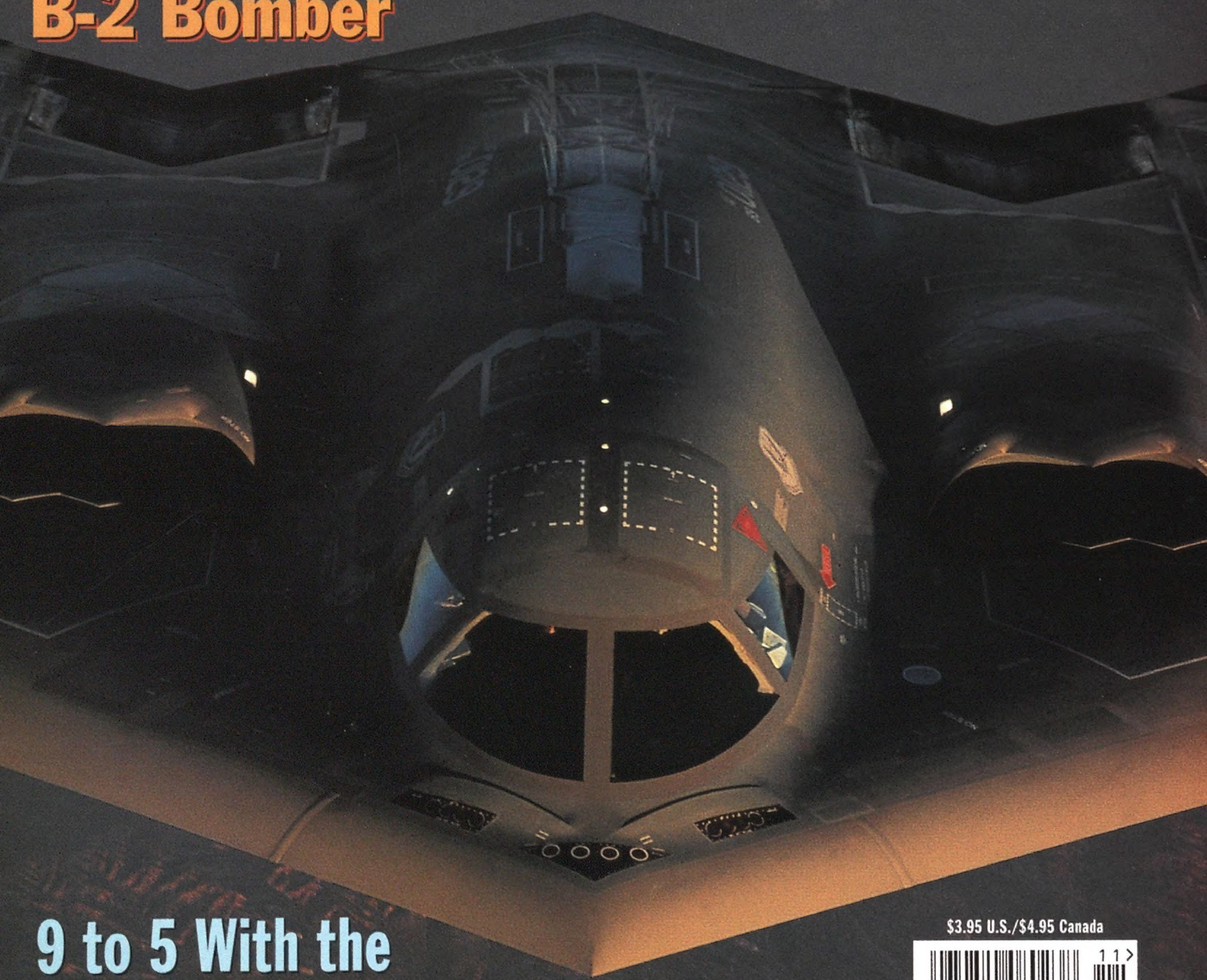
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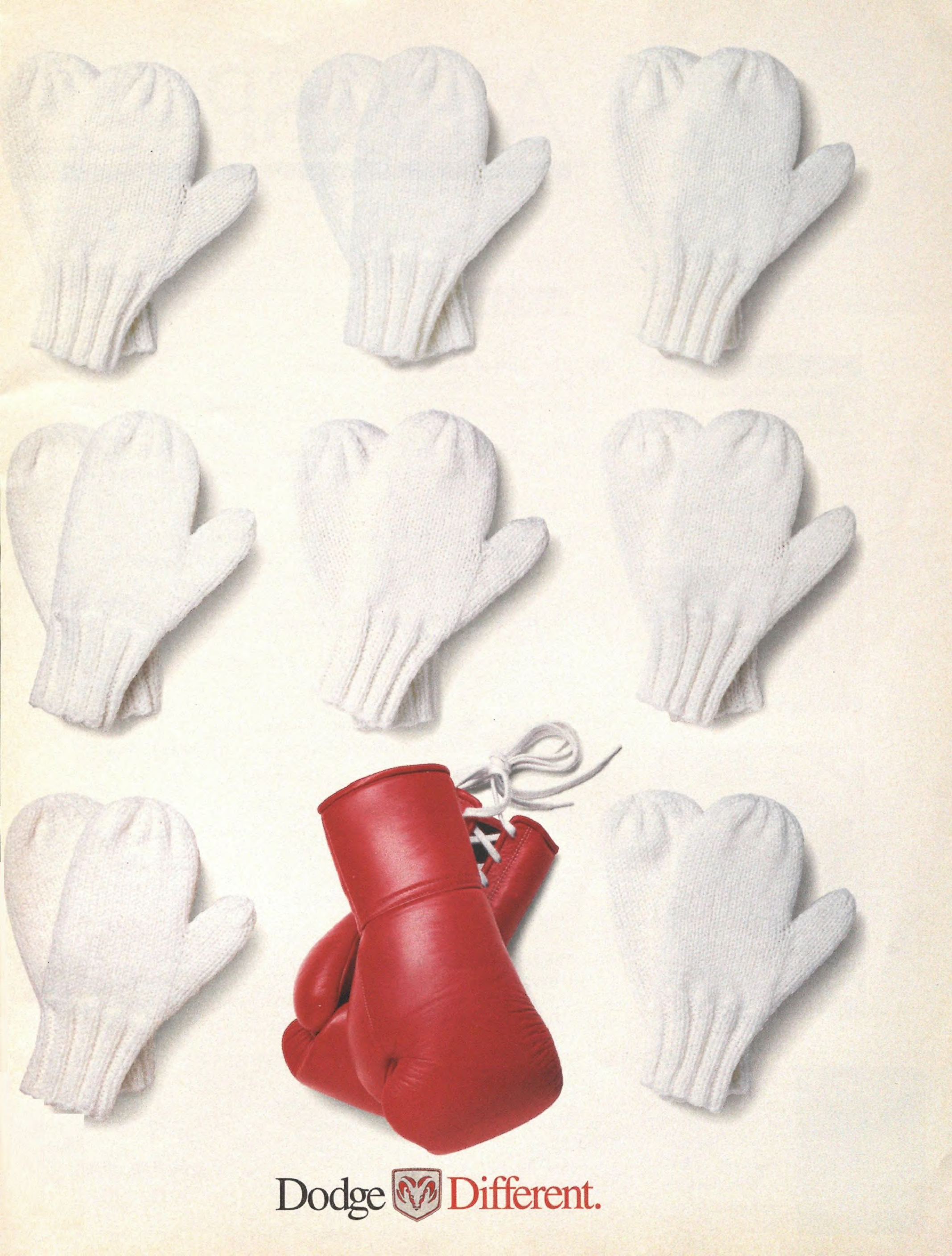


9 to 5 With the Wright Brothers p. 58

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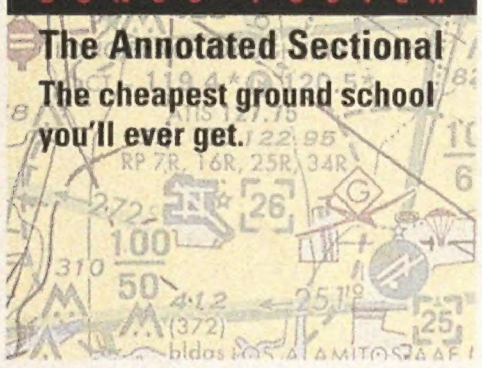


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October/November 1999
Volume 14 • Number 4

BONUS POSTER



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In Ted Carlson's shot of the B-2, nostril-like sensor ports, hooded engine intakes, and the cockpit's evil grin all say Don't mess with me.

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TOP SECRET

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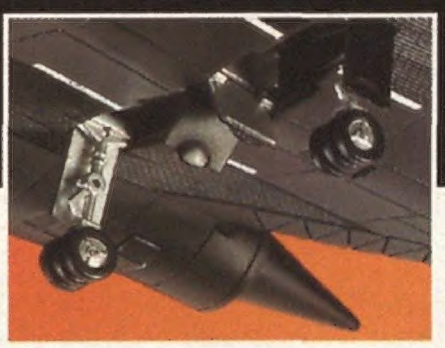
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When a temblor struck Turkey in late August, televised images of the devastation appeared within hours. But Turkey's rescue services were slower to react, and families of trapped victims despaired as time ticked away. So the rest of the world had to do what Turkey could not, and two days after the quake struck, some 2,000 aid workers had arrived with tons of equipment. Among the rescuers were specially trained firefighters from Fairfax County, Virginia. How did they all get to Turkey? Does anyone really need to ask?

This disaster, like others we've covered in our pages, depended on airlift to provide relief, and such missions are flown by the air forces of the United States (the 436th Airlift Wing flew the Virginia team) and other nations, supplemented by civil operators who can fly tons of supplies on short notice. There's nothing dramatic about relief missions aside from the fact that everyone involved has to hustle to get the stuff to where it's needed in time to save lives. So you won't see much about the flying on television.

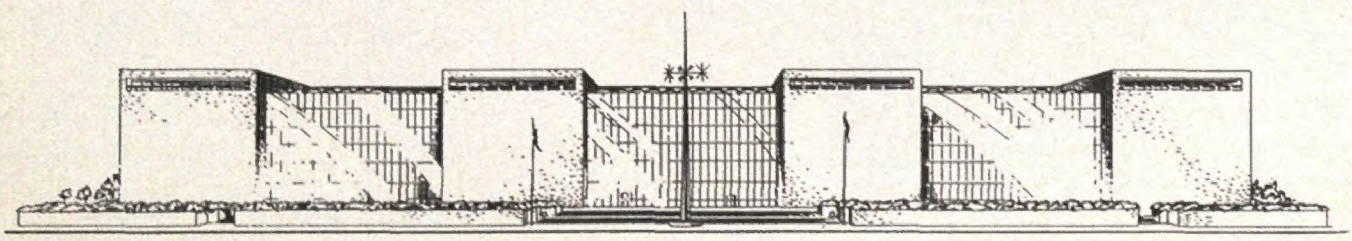
And yet airlift is usually the only way to gain access to a disaster area. Roads are blocked and bridges are swept away, as happened in Central America during the fall of 1998, when five-sixths of Nicaragua's highways were damaged or destroyed by Hurricane Mitch.

Though reports said cranes used in Turkey came from Europe by ferry, sealift is too slow for rescue efforts, which are a race against time: Experts say the survival rate for trapped victims diminishes rapidly after 96 hours. Port facilities can be damaged so badly that vessels can't dock and unload. But airports and runways are robust. Most runways are built to bear heavy loads and usually come through in better condition than even the best highways. And there are few structures around them to collapse and block their use.

Another airlift this summer gave a different twist to the meaning of the word. Instead of a fleet of C-5s, the Citation Special Olympics Airlift was made up of business jets donating flights to Raleigh, North Carolina, where the 1999 Special Olympics were held. On June 25, Raleigh-Durham International Airport set its own all-time record, with a landing every one to three minutes. Almost 300 aircraft transported some 2,000 participants to the site of the games. Operators of Cessna Citation jets began offering the flights in 1987, and were it not for the aircraft owners and crews, many of the athletes would not be able to attend.

The link between aircraft and humans in need dates back to the early days, as you'll see in "Working for the Wright Brothers" (page 58), in which the author refers in an almost off-hand way to what must surely have been one of the first water rescues ever performed in an airplane. Igor Sikorsky was said to have intended his helicopter for humanitarian purposes such as rescue. Natural disasters, famine, dislocation, even political or economic collapse—such events will persist and, as the global population grows in the short term, may even become more frequent. What's more important is that during this century we needy but intelligent humans invented the machines that can make a difference in the outcome, and that's just one of many reasons why we build museums to hold them.

—George C. Larson



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LETTERS

Aviation's Loss

I second your "In Memoriam" regarding National Air and Space Museum Director Don Engen (Viewport, Aug./Sept. 1999). I am proud to be able to say that Don was a friend and, without a doubt, the finest gentleman I have known. We are all diminished by his passing, but enriched by having known him.

—Addison S. Thompson
Past President
Society of Experimental Test Pilots
Palmdale, California

I learned to fly in 1968, a time when general aviation's safety record was not something to brag about. I also had the pleasure of flying "through" Mr. Engen's tenure at the Federal Aviation Administration and being part of many dramatic improvements in flight safety. From then through his career at the Museum, I have enjoyed watching him work. We will all miss him.

—Don Waltenspiel
Santa Rosa, California

I can't think of a better tribute to Don Engen than naming the Museum's proposed Dulles Annex in his honor. Admiral Engen served his nation in war and peace. The annex was one of his top priorities at the Museum. It would be very fitting for Senator John Warner of Virginia to propose that the annex be named in Admiral Engen's honor.

—Randy Jennings
Chantilly, Virginia

The Legend Lives On

I have visited the surviving XB-70 many times at the Air Force Museum, and even 35 years after its first flight, it remains an inspiring sight. That said, I feel the need to point out a minor flaw in "The Legend of the Valkyrie" (Aug./Sept. 1999). John Sotham repeated the story that during one flight, Joe Cotton used a paper clip to jump two circuits and lower the Valkyrie's malfunctioning nose gear. While such an incident did indeed occur, no paper clip was involved. As I recall from a conversation with pilot Al White, he and Cotton found themselves with a nose gear that would not deploy and a set of main gear that would not retract. The crew faced the prospect of having to abandon the aircraft—the XB-70's unique configuration prevented a landing on the main gear with the forward gear retracted. The aircraft's nose would have dug itself into the runway, with dire consequences to the



"It's Alice Kramden!"

crew. As the XB-70 orbited Edwards Air Force Base, an engineer on the ground suggested that one of the air crew try to lower the forward gear by crawling into the equipment bay behind the cockpit and jumping a circuit. While passing this information up to the aircraft over the radio, the engineer asked if either of the men had a paper clip. It was this comment, recorded on tape, that produced the ongoing myth. In fact, neither pilot had a paper clip, but Cotton was able to find a small piece of wire. He climbed into the back and, risking a nasty electrical shock, jumped the circuit and saved the aircraft.

—Daniel Waltimire
Revloc, Pennsylvania

As a sound recording engineer for the motion picture (later TV) department of Rockwell International's El Segundo, California division, I recorded radio communication in the XB-70 program. During the final flight of the second XB-70, I was listening to the radio talk when I heard chase pilot Joe Cotton call out: "Mid-air, mid-air!" From what he said and what was disclosed in the following investigation, it appears the XB-70 did not strike "an F-104 during a formation photo-op flight," as Sotham writes. It was the other way around: Joe Walker, flying the F-104, was behind the XB-70 and was sucked into the engine vortex from the right rear of the XB-70. Others soon joined me in listening to that radio communication as Cotton gave a running commentary all the way to ground impact and confirmation that pilot Al White was the one who safely emerged from the ejection capsule.

—Martin Halperin
Woodland Hills, California

The Air Force attempted efforts to keep the B-70 alive in other guises. The first XB-70 had not yet flown when, in 1961,



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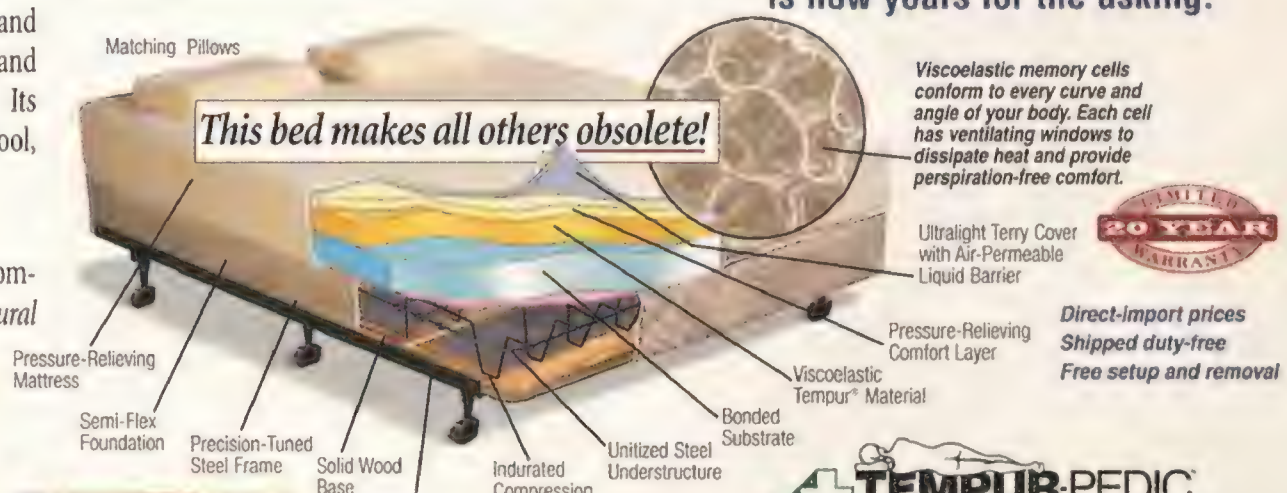
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Before entering, please read the detailed rules, which are posted on page 92.

Winner of the fourth UFO Contest is **Thomas Sebik** of Colorado, who correctly identified the **Beechcraft Twin Quad**, a prototype airliner with four buried engines driving two propellers and a twin-keel belly for emergency gear-up landings.

the Air Force proposed a "reconnaissance-strike" vehicle, the RS-70—the numerical predecessor to the SR-71 Blackbird. Under this concept, 60 aircraft would be procured to (1) carry out reconnaissance of enemy targets during a missile attack, and (2) examine targets and, if required, attack them immediately with air-to-surface missiles. Secretary of Defense Robert S. McNamara opposed the concept, arguing that there were better and cheaper ways of obtaining both of these capabilities. The Air Force also considered employing the B-70 as a transport aircraft. General Thomas D. White, Air Force chief of staff, told Congress in January 1960 that the B-70 could carry 60 or more people. As an example, he said that flying from the U.S. West Coast to Taiwan at Mach 3 would take four hours. But the era of the high-altitude strategic bomber was over.

—Norman Polmar
Alexandria, Virginia



"I believe we've met before, but your head was bigger."

Aerospace development went awfully far awfully fast once upon a time, and the XB-70 was a perfect example. But I'm missing something: This aircraft was a bomber, right? In the gorgeous cutaway, I can't find the bomb bay.

—Mark Ranzenberger
Harbor Beach, Michigan

Editors' reply: Several readers asked about the bombs, as well as what would happen if you opened the bomb bay doors at Mach 3. Because production of the XB-70 was canceled before the rollout of the first aircraft, the Valkyrie's offensive capabilities remained untested. However, both airframes had operational weapons bays that featured flat, translating doors that were designed to be opened at multi-supersonic speeds to allow the delivery of up to 25 tons of free-falling nuclear or conventional bombs. In practice, the weapons bays of both

XB-70s housed test equipment. There were also early proposals to hang guided missiles from pylons attached to the Valkyrie's wings, but launching those weapons would have required the aircraft to slow down, which would negate what was thought—before the advent of surface-to-air missiles—to be a great advantage: high-speed, high-altitude weapons delivery.

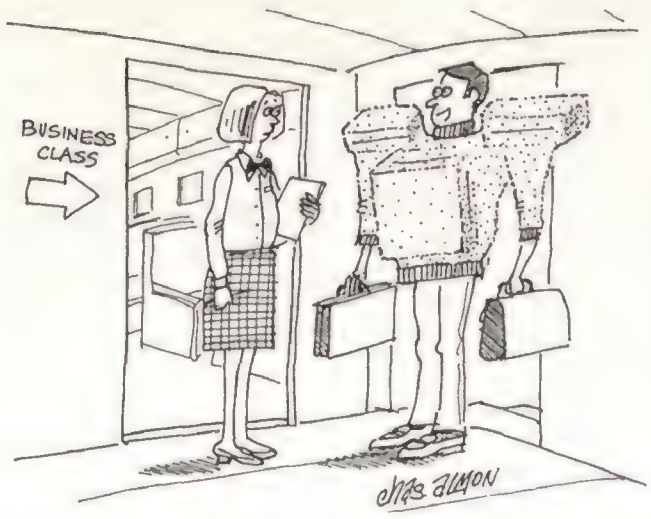
Revising Lindbergh

Tom Crouch chides Lindbergh author Scott Berg for "not sharing" the aviation hero's "deeper thoughts on race and civilization"—thoughts that today are anathema (Reviews & Previews, June/July 1999). But he ought to ponder a few things. First, the 1930s was a very different time. Lindy's xenophobic views about "the pressing sea of Yellow, Black and Brown" were widely shared in this country. Remember, Lindbergh's opinions were published not in some extremist newsletter but in the stodgily mainstream *Readers' Digest*. Second, in his flirtation with Hitler's Reich, Lindbergh was hardly alone. Not long before the U.S. economic boycott of Germany (itself controversial) the *Los Angeles Times* praised the 1936 documentary *Olympia*, directed by Hitler's pet filmmaker, Leni Riefenstahl, and a major Chicago newspaper carried admiring full-color supplements on the Nazis' elegant uniforms, flags, and regalia. In short, Lindbergh was a man of his time, and surely flawed as Crouch notes. But just as he shouldn't be mythologized, neither does he deserve scapegoating for espousing once-popular, now-banned opinions.

—David Walsh
Silver Spring, Maryland

Searching, Searching . . .

"Signs of Light" (Aug./Sept. 1999) asks why the search for extraterrestrial life has turned up nothing. SETI efforts are based on researchers' faith in the famous Drake Equation, which they use to suggest that there is a possibility of intelligent life on other planets. A careful analysis of the Drake Equation should actually come to quite the opposite conclusion. There may very well be hundreds or even thousands of planets in the galaxy capable of supporting some forms of life, perhaps even a few capable of supporting abundant life. However, there is virtually no chance that any of that life will have developed intelligence, let alone technology. Of millions of species on this planet that have been present at one time or another, only one



"Two pieces of carry-on. What's the problem?"

has been able to evolve intelligence. There is no inevitable upward climb by species toward intelligence. Rather, the development of intelligence required the exceedingly unlikely presence of a species—humans—that was almost, but not quite perfectly, adapted to its environment. Many species can run, swim, fly, see, hear, smell, hunt, and defend themselves better than we can. Those species that are perfectly adapted to their environments are in no need of intelligence to be able to thrive in their niches. Species that are not well adapted go extinct. It took a one-in-millions (or worse) combination of poor (but not too poor) and good (but not too good) adaptation for us to get far enough along to survive and develop intelligence and ultimately, technology. The hope that this combination of a benevolent planet and fortuitous evolution could occur more than once in a galaxy is so remote as to not be worth any real effort to pursue.

—Dennis B. Cotter
Grosse Pointe Park, Michigan

Mach Debate

There are two other interesting incidents concerning the race to Mach 1 ("Mach Match," Dec. 1998/Jan. 1999). The first involves a test flight of the Me 163B V16 Komet on July 6, 1944. This aircraft was modified with an auxiliary cruise chamber to extend powered flight time from 2.5 to 6.5 minutes for the projected "C" series. During the test flight, the aircraft attained a speed of 702 mph at approximately 18,000 feet—or Mach 0.99—while climbing at an angle of between 45 and 50 degrees. The pilot, Rudolph Opitz, cut the rocket motor as the aircraft's Mach limit had been exceeded (p. 110, *Rocket Fighter*, William Green, Ballantine Books, 1971).

Another incident occurred in 1946, when the Russians took over a German wartime project on a high-speed research aircraft, the DFS-346. According to the

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designer, Felix Kracht, the swept-wing aircraft had a maximum design speed of 1,717 mph (Mach 2.6) at 114,800 feet and enough thrust to climb vertically. The Russians had the Germans finish building the plane in Russia. The flight plan was almost identical to that of the U.S. X-1. In May of 1947, a captured B-29—forced to land in Vladivostok in 1944—carried the DFS-346 to 30,000 feet for a powered release. With former Siebel test pilot Wolfgang Ziese at the controls, the DFS-346 attained a speed of 683 mph, or approximately Mach 1.1. The Russians attempted to repeat the German pilot's success with two of their own pilots in copies of the DFS-346 that they had built themselves, but both were destroyed due to faults in the release gear. The Russians never pushed their claim of having been first to break the sound barrier, five months ahead of the Americans, because it was a German pilot in a German-designed and -built plane that did it (pp. 636–638, *German Aircraft of the Second World War*, J. R. Smith and Antony Kay, Putnam, 1975).

—Michael T. Klewin
Lawrenceville, New Jersey

I knew the DC-7. That's no DC-7.

Take it from a guy who knows them: That is no DC-7 ("Mistaken Identity," Letters, Aug./Sept. 1999). It's a DC-6, which had Pratt & Whitney R-2800 CB water-injected engines (the best piston engines ever built!). The DC-7 had Wright 3350s, which had three power recovery turbines on each engine. They acted as a collector for the exhaust. The steel hood exhaust stacks, two on one side of the engine and one on the other, would be plainly visible extending from the large cowl flaps of the DC-7. The DC-6 had much smaller cowl flaps, just as we see in the picture.

—Capt. Henry Germain
Flying Tigers (ret.)
Thousand Oaks, California

Glory Days

"Remnants of Glory" (Aug./Sept. 1999) was a wonderful look at some of the icons and remains of aviation's past. However, Russell Munson missed a gem when he did not stop by the College Park Airport. Founded when Wilbur Wright came here in 1909 to teach military officers to fly the government's newly accepted "aero" (now on display in the National Air and Space Museum), this airfield is home to many significant

aviation firsts and personalities. The foundations of the military's first Army Aviation School, dating to 1911 and 1912, are outlined in brick and stand adjacent to the hangar that housed the first civilian airmail craft. Though the first Postal Airmail flight took off from College Park on August 12, 1918, this hangar and its unusual compass rose feature—both restored—were built in early 1919 and have stood the test of time. Though little else remains of the field's heyday, a new 27,000-square-foot museum dedicated to the history of College Park Airport opened nine months ago.

—Catherine W. Allen
Director, College Park Aviation Museum
College Park, Maryland

The photo of the TWA building in Kansas City, Missouri, was worth the price of my entire year's subscription (and the one I give my dad!). As the son of a TWA pilot born and raised in Kansas City, I have many fond memories of picking my dad up after flights at that very building. After TWA left, the building sat abandoned for several years before it became a tennis club. My older brothers got memberships there and I would wander through the building while they practiced in the hangar, which had six or seven courts in it. That was a great place to explore for a young man enamored of aviation. I'm glad to see the building is in good shape and is back performing its original function—storing airplanes.

—William A. Jensen
Manitowoc, Wisconsin

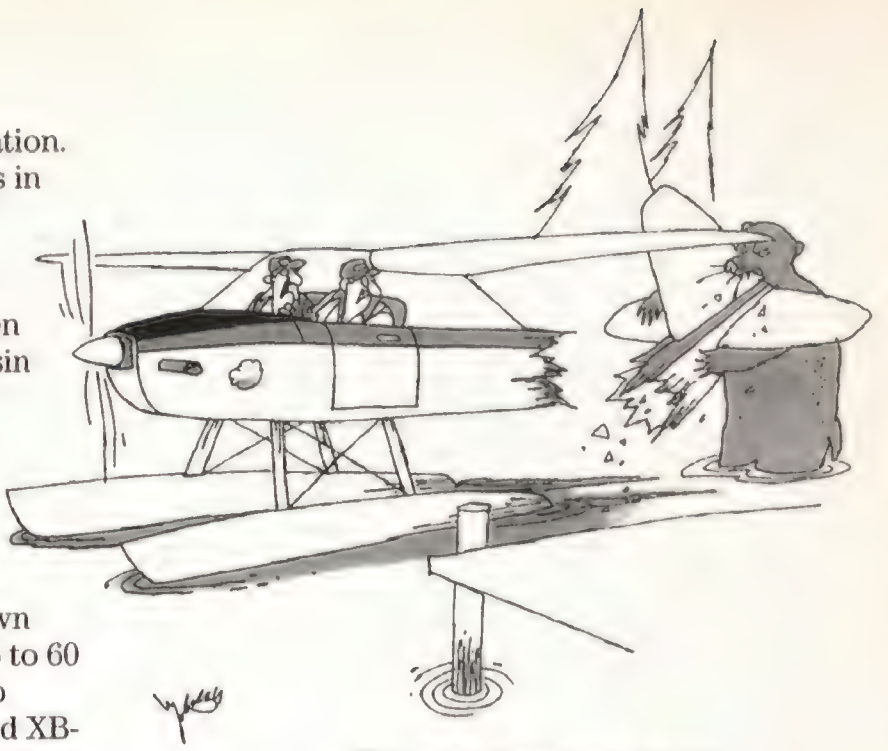
Corrections

Aug./Sept. 1999 "The Legend of the Valkyrie": The XB-70A's wingtips folded down from 25 to 65 degrees, not 25 to 60 degrees; XB-70A number two crashed in 1966, not 1967; and XB-70A number one flew another two years and eight months, not a year and a half.

"Tomorrow's Storm": The pilot pictured on the bottom of page 66 is Phil Kenul, not Ron Philippsborn.

"Unidentified Flying Object" contest: The aircraft in the photograph is not a canard design. As many readers noted, it is a centerline-thrust multi-engine aircraft.

June/July 1999 "Aero Acres": We regret misspelling Harvey Hodgin's name.



"We must have caught too many salmon."

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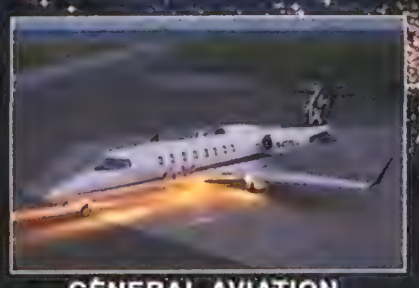
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On Your Mark...Get Set...MAINTAIN!

U.S. Air Force Technical Sergeant Darren Langen and his team of weapons loaders grunted as they hefted a Sidewinder air-to-air missile and carried it toward a Royal Air Force Jaguar GR.3 attack jet. No doubt Langen and his crew would have rather been working on the familiar F-15E nearby, but their Eagle was being tended by the Italians...or was it the Belgians? Meanwhile, the German Navy team blitzkrieged a Dutch F-16.

Weapons load teams from eight nations were at the NATO Pit Stop Challenge at the Royal International Air Tattoo last July to put on their best performance, but with a twist: They couldn't work on their own aircraft. The event, held at Royal Air Force Fairford during a rare blistering English heat wave, was a mix of hardcore military demonstration, spirited competition, and American-style showmanship.

The aircraft to be loaded were parked before a camouflage-netted shelter where the team members, each in colored vests for identification, rested between rounds. Except for the vests, the setting was much as it would be in wartime, with crews re-arming aircraft returning from missions. While the teams loaded inert bombs and missiles, a TV crew circulated and zoomed in on dirty fingers tightening the sway braces on a Mark 84 or a sweaty face concentrating on connecting an umbilical to a Paveway laser-guided bomb. The action, and each team's current standing, appeared on a stadium-style video screen held above the shelter by a crane.

RAF narrator Flight Lieutenant Helen Williams patiently intoned stats on each aircraft's performance, the ordnance it carried, and, most importantly for the confused crowd behind the security fence, which color-coded team was which. On Saturday, clots of airshow-goers peered at the action as she described the blast pattern of a CBU-87 cluster bomb in a perfectly modulated, Lexus-commercial voice, and then—WHOOSH, the B-2 took off, heads snapped around in unison, and half the audience disappeared in a camera-fumbling, stealth-crazed stampede. It was a tough sell sometimes, sort of like hyping the Zamboni crew during the Stanley Cup finals.

In addition to its billing as entertainment, the Pit Stop Challenge had real-world relevance in keeping with the airshow's 1999 theme, "NATO Interoperability." Even though the teams had started training a mere two days before the competition officially started on Saturday, missteps were rare. "We had to learn everyone else's...procedures, and everyone uses different loading equipment," said Corporal Erik Van Den Boom of the Royal Netherlands air force. "But the most important thing is to work safe." Regardless of the aircraft or weapon, the basic skills are the same, and many of the same missiles and bombs are used by a variety of NATO countries, said Van Den Boom's teammate, Sergeant Eize Eyzenga.

Each team was watched by an evaluator native to the aircraft being serviced, and points were awarded based on how closely, and how safely, the members followed procedures. Haste was good, but speed wasn't always a plus: Points were deducted if a team finished quicker than the minimum time the evaluators set for a safe load. Langen, a veteran of real-life NATO air operations staged from Italy, expected his fellow Pit Stoppers to be top-notch troops, and he wasn't disappointed: He'd worked alongside other nations' load teams when the stakes were higher than just a trophy. "When [the bombs] are all live," he said, "you want to know everyone knows their business."

The teams shared high standards, but differences—at least in style—emerged. The U.S. Air Force team, with crisp



CHRISTOPHER CORMACK (2)



uniforms, shiny steel-toed boots, and crewcuts aplenty, worked alongside a Dutch team whose evaluator sported a dangling gold earring and hair that hung over his collar. Another team wore sneakers. Differences in how each country trains its crews also emerged. "We're not allowed to run," Eyzenga said. "The Americans can run."

And run they did. After the last round late Sunday afternoon, the U.S. Air Force team won the overall title. Awards were also given for best performance on individual aircraft—the Royal Navy won for loading a Tornado, the Belgians for their work on the F-15E, and Van Den Boom (who should have gotten an honorable mention for having the best name for someone who handles explosives) and his Royal Netherlands team won for arming an RAF Jaguar.

As the winners were announced, the airshow was being broken down, and some of the aircraft started to roar into the sky toward home. No matter—to the Pit Stop crews, the real action had been on the ground.

—John Sotham

UPDATE

And the Winners Are...

NASA has selected two missions from its 1998 low-cost Discovery program proposals ("And the Space Probe Is...," Soundings, June/July 1999). The Mercury Surface, Space Environment, Geochemistry, and Ranging mission will image Mercury, while Deep Impact will fire a projectile into comet P/Tempel 1 to expose interior ice and rock. Both probes are scheduled to be launched in 2004.

NASA's Little Helper

To master the light saber in *Star Wars*, Luke Skywalker sparred with a mysterious self-propelled ball. On future NASA missions to the moon, Mars, and beyond, similar mobile companions will likely roam autonomously inside spacecraft to assist astronauts.

Such a spherical robotic device, a personal satellite assistant, is currently roaming around NASA laboratories. Outfitted with a modicum of machine intelligence, cameras, and sensors, the basketball-size PSA can snap pictures and monitor environmental conditions like temperature and gas levels for astronauts or remote operators. The device navigates through simulated microgravity with help from tiny battery-operated fans.

"The space balls will extend the abilities of humans," says Ken Ford, director of the information technology division at NASA's Ames Research Center in California. "Crews will be able to do more work, more efficiently."

Not surprisingly, the balls will be assigned much of the drudgework of space exploration. PSAs will monitor experiments, documenting changes, for example, in lab animals or bacterial growth in petri dishes that would be undetectable by the human eye.

Astronauts or Earth-based scientists will be able to command the PSAs to calibrate an instrument or track inventory. Equipped with microphones, speakers, and flat panel displays, the PSAs will facilitate audio and video conferencing. Computer systems will also communicate wirelessly with the PSAs.

NASA scientists hope to test the first completed PSA on a space shuttle flight in 2002. But first the team wants to shrink the prototype orb to the size of a softball. And the engineers need to perfect navigation and control, so that the balls recognize and avoid bumping into astronauts and equipment.

Because battery life will be short—30 minutes to two hours—the PSA will have to dock frequently with a charging station. "It steals from the idea of an R2D2," says project team leader Yuri Gawdiak, referring to the Star Wars robot, which recharged itself by plugging in.

Even after refinements, PSAs won't be anywhere near intelligent enough to replace the space agency's finest, Gawdiak says. Astronauts should therefore warmly welcome their newly contrived companions.

—Julie Wakefield

Howard's End

In the Golden Age of aviation, few names were more golden than Benjamin "Benny" Howard. Pilot, designer, and builder, his various DGA (Damned Good Airplane) models dominated the racing circuit in the mid-1930s, culminating in *Mr. Mulligan*, DGA-6, winning both the Bendix and Thompson Trophy in 1935. Subsequently his DGA-15 high-wing monoplane became the aircraft of choice for celebrities and executives, serving the same functions that "people use Lears and Gulfstreams for today," says Dave Schober, president of the Howard Aircraft Foundation.

In World War II, the DGA-15 design was modified for military service. The Howard Aircraft Corporation made more than 500 trainers and ambulance aircraft for the armed forces, most of them at its factory at DuPage Airport, near Chicago. Production ceased in 1944 and the factory burned down in 1987, its role in the war effort all but forgotten. But thanks to the interest of Howard aficionados and local historians, the story of the aircraft and the people who made them has been resurrected, a rediscovery celebrated at the Howard Aircraft Reunion at DuPage Airport last August 1. Seven Howards, restored to DGA-15 luxury configuration, flew in from as far as Texas, and were open for inspection on the ramp.

"I don't remember all those instruments," said 77-year-old Lorraine Richardson of West Chicago, eyeing the digital avionics stack inside a gleaming red Howard. "I used to put the wires in that connect these, and there wasn't that many," she said. "Look at these modern covers on the wheels. We didn't have those. Fancy doors. Wow!"

At its peak, the company had more than 2,300 employees. About 50 were among the 200 reunion attendees. If recollections of factory operations were cloudy after half a century, it wasn't just a

matter of fading memory. "You didn't go around wondering what the other fellows were doing," recalled Theresa Ward Redmond, a former inventory worker whose father was a plant executive. "There was this thing about possible enemies being around. You minded your business and that was that."

Inside the terminal, former employees pored over albums filled with newspaper clippings and photos. War-era songs played in the background. Friendships suspended for decades were reactivated. Frank Rezich and Elmer Toman were clapping each other on the back. "We last saw each other 50 years ago," Rezich said. Rezich began working at the company's factory at what is now Chicago's Midway Airport, and was one of the few on hand to have worked with Benny Howard. "He talked to everybody—he wasn't a pretentious man," Rezich said. "But he was very demanding. You had to build it to perfection, and the airplanes we delivered looked like those outside."

DuPage airport marketing director Brian Culpin, who helped organize the event, welcomed the crowd, and unveiled a display of company artifacts and history that will become a permanent exhibit at the nearby St. Charles Heritage Center.

At a roundtable discussion, past employees were joined by others with emotional bonds to the aircraft. Charles Donovan, whose search for Howard history helped spark the reunion, recalled his wartime service in the instrument trainer. "The beautiful airplanes we see out on the runway were my home for several hundred hours of training Navy pilots," he told listeners. "This aircraft played a very significant role in the development of instrument flying as we know it today."

Marv Abramson's mother worked at the factory, and he recounted a moment that,

DAVE DIETER



A new landmark graces the Huntsville, Alabama skyline. Last July, just in time for the 30th anniversary of Apollo 11, the U.S. Space & Rocket Center museum erected a full-size replica of the Saturn V launcher. It took a 40-story crane to raise the 363-foot replica, the world's only upright Saturn V exhibit. A 400-foot gantry, which will house a restaurant and exhibit areas, will be added next to the replica in the spring.

UPDATE

A Dream Sadly Realized

The ashes of geologist Eugene Shoemaker are now on the moon ("In Memoriam," Soundings, Oct./Nov. 1997). The remains were carried by the Lunar Prospector spacecraft, which intentionally crashed in a crater at the moon's south pole last July on a mission to probe for lunar ice. A symbolic portion of ashes was placed in a brass-foil-wrapped capsule inscribed with the image of a comet, representing Shoemaker's numerous comet co-discoveries, and an image of Meteor Crater, which the geologist proved was created by an asteroid impact.

PAMELA KLEIN

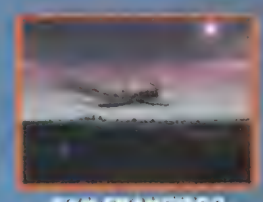


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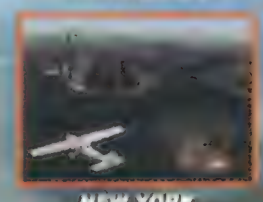
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repeated tens of thousands of times, changed the fabric of society. "I remember when my mother started wearing pants," he said. "They had her doing upholstery work on the inside of the plane."

Frank Flores, now a 727 pilot for TWA, related his father's attachment to his DGA. "Probably one of the biggest loves of his life was the Howard," he said. His father bought the airplane in 1957, on the day Frank was born, and made national news six years later when he and a passenger were rescued 50 days after crashing in the Yukon wilderness in the winter. Frank found the untouched wreckage on his 35th birthday, and plans to restore the Howard and retrace his father's route.

Outside on the ramp, Roland Rippon, whose DGA would win an award at the Experimental Aircraft Association fly-in at Oshkosh, Wisconsin, the following day, summed up the allure of the aircraft for owners of the 30-some Howards flying today: "They're big, they're beautiful, they're rare, and they're a damn good airplane."

—James Wynbrandt

Comet's Tale

During my aeronautical engineering apprenticeship in the de Havilland Technical School at Hatfield, England, in the 1940s, I was often asked to show visitors around the factory. Apprentices had been through most factory departments, and we were supposed to know what went on. The reward was often a free lunch at the Comet Hotel afterward. Some of us actually wore ties.

American visitors were interested in our twin-engine Dove business aircraft, but they were far more interested in our Comet 1 jetliner, which we were building unobserved so the Americans would not catch us up, or so we hoped. As an apprentice I could show visitors anywhere except E Block—Experimental. I was always suitably inscrutable and showed them our Vampire jet fighter and DH 108 experimental jet. The world knew that we were building a jetliner, but nobody knew what it looked like. Some visitors thought it had no tail, like our little DH 108 experimental swept-wing jet, and we did not disabuse them of this idea.

At 6:17 p.m. on July 27, 1949, our jetliner shed its veil of secrecy and lifted off the Hatfield runway to change the world. I never imagined that 50 years later I would be quaffing champagne at the Comet Hotel to celebrate the world's first jetliner in the presence of its pilots, designers, and builders.

Last July, British Aerospace and the Royal Aeronautical Society brought 150 of us together again. The gathering was saluted by a Royal Air Force Nimrod, which flies on the same wing as the Comet. The Nimrod flew over the Comet Hotel at the precise minute the prototype Comet 1 had climbed into the future.

Comet 1 was built between 1947 and 1949. Code-named DH 106, signifying de Havilland's 106th design since founder Sir Geoffrey's Edwardian biplanes, it was the first airliner designed for jet engines. The 106 would double the speed and the cruising altitude of contemporary propeller airplanes.

To me, the 106 was from another planet. I can still feel the buzz of disbelief as I sneaked into E Block (no ID badges needed in those days) and gazed upon the gleaming aerodynamic aluminum of DH 106/G-5-1/G-ALVG.

In the 1940s, jets were for fighter pilots fitted with oxygen masks and pressure suits. Jets were like rockets, guzzling fuel in minutes and too often relieving themselves of turbine blades. Now we had designed a jet engine with the reliability to power a passenger aircraft. The Americans eventually caught us up with Boeing's prototype for the 707, but the Comet 1 paid the pioneer's debt, revealing in two explosive crashes that continual pressurization-decompression cycles accelerated metal fatigue of the Comet's thin skin.



DH PHOTO (2)



The flight test team, at center in white flightsuits, was saluted by the construction team after the first flight.

On the airliner's anniversary, a warm, sunny day in Hatfield, we celebrated the birth of jet-powered air transport. Guest of honor John Cunningham, commander of the maiden flight, said just the right few words with his usual modesty and charm. He, copilot John Wilson, and test observer Tony Fairbrother accepted specially commissioned Comet paintings. The ladies, including de Havilland cousins Anne Essex and Hollywood star Olivia, received bouquets to rival the Chelsea Flower Show. A marquee on the Comet Hotel's pine-shaded lawn sported a de Havilland flag, dispensed champagne, and offered scholarly books to remind us that although the Comet 1 crashed, the Comet 4 served 20 airlines safely and profitably for more than 20 years.

—J.M. Ramsden

UPDATE

Champlin 1, Navy 0

A judge in the U.S. district court in Miami ruled last July that Doug Champlin may proceed with his salvage of a Douglas TBD Devastator that is under 500 feet of the Atlantic off the coast of Miami ("Whose Planes Are They, Anyway?," Oct./Nov. 1998). Although Judge James Lawrence King avoided ruling on the issue of whether the Navy had abandoned the airplane, he ruled that because the TBD is in "marine peril," the U.S. Navy cannot refuse Champlin's salvage effort. The court will put a monetary value on the operation, which the Navy must pay Champlin if it wants to claim the aircraft. The Navy must also pay Champlin's court costs. King's ruling opens up the possibility that salvagers can pursue all Navy aircraft that can be considered abandoned. The Navy is expected to appeal the decision.

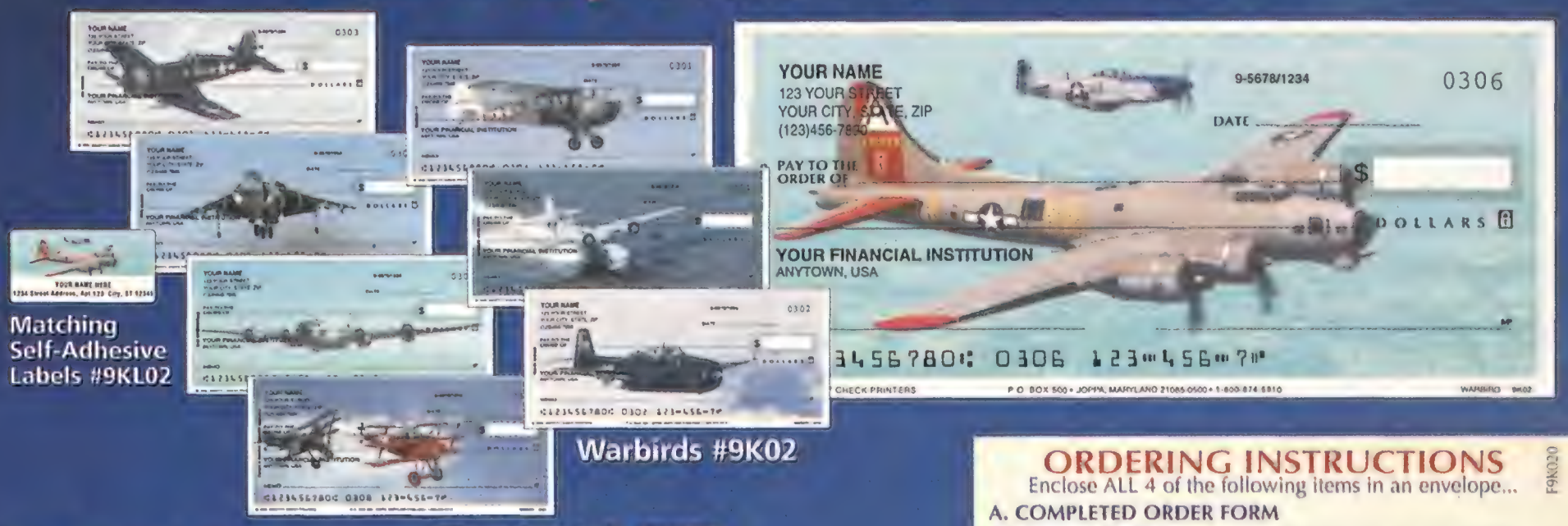
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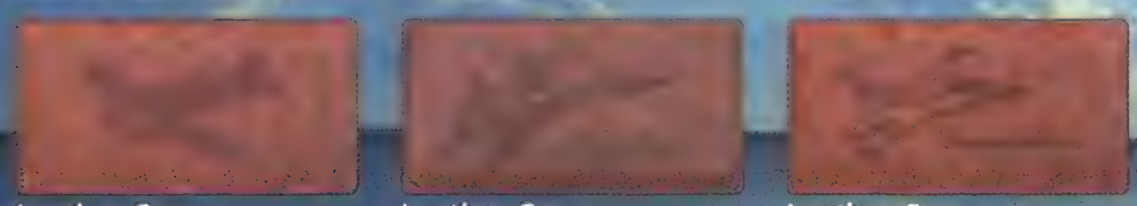
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Deciphering Venus

It's been five years since NASA's Magellan spacecraft returned its last close-up radar image of Venus, and Jim Zimbelman is still puzzling over what the pictures mean. He unrolls an oversize black-and-white glossy and smooths it out on a table. It shows a region of rugged plains in the Venusian northern hemisphere, a quadrangle that includes Kawelu Planitia and the western edge of Guinevere Planitia. The fantastic swirls and streaks, in every shade of gray, tell stories of volcanism, meteorite impact, and violent upheaval—that is, if you know how to interpret them. Zimbelman thinks the photo is "beautiful, almost disturbing" in the amount of information it contains.

A geologist with the National Air and Space Museum's Center for Earth and Planetary Studies, Zimbelman is one of about 30 researchers being funded by NASA to convert Magellan's pictures into knowledge, to make this particular *terra* more *cognita*. He is responsible for producing authoritative geologic maps of three of Venus' 62 quadrangles, at a scale of one to five million. It sounds like one of science's smaller problems until you realize that each quadrangle covers half to two-thirds the area of the United States, and the world expert on all this vast territory is none other than Jim Zimbelman.

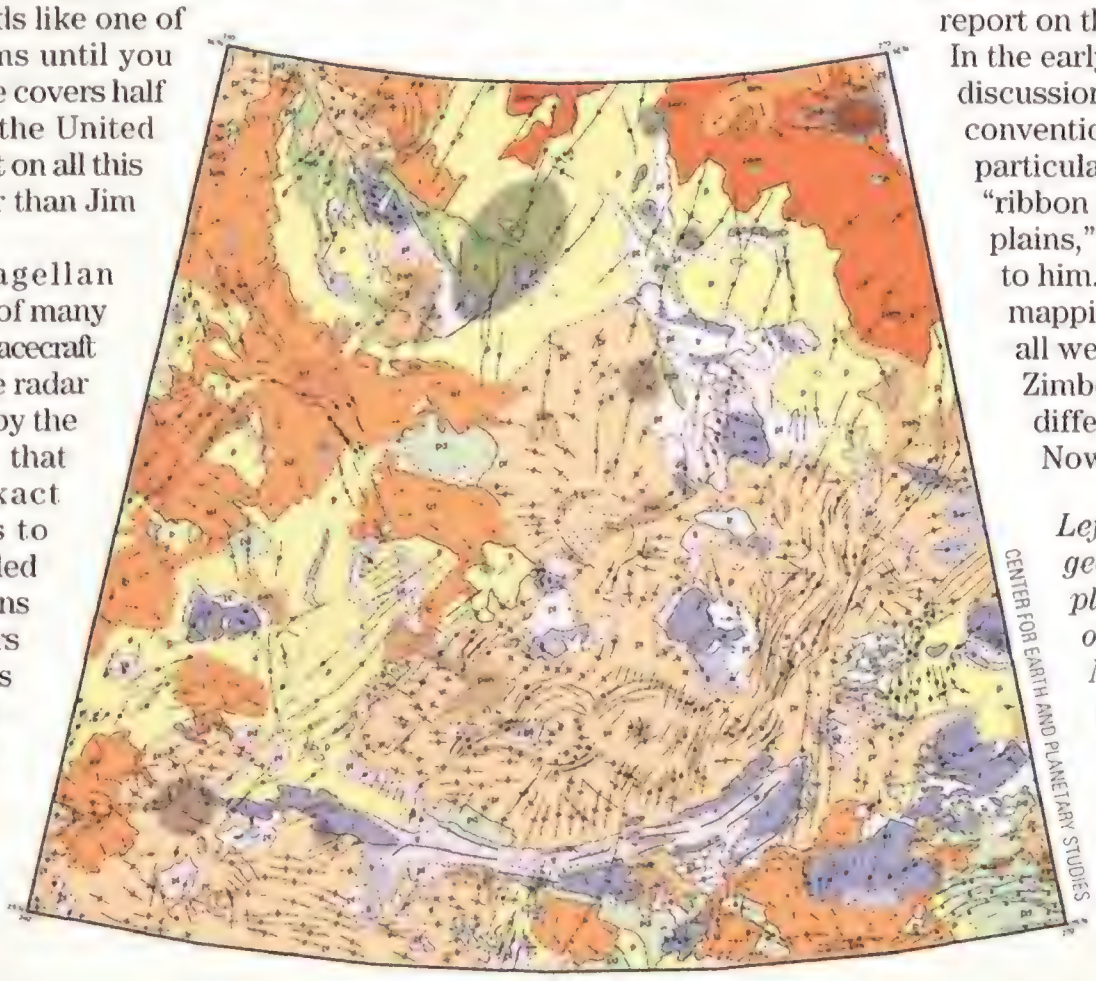
He starts with a Magellan photomosaic, a composite of many image strips returned by the spacecraft years earlier. Since then the radar image has been formatted by the U.S. Geological Survey so that all the features have exact coordinates. His task is to interpret the geology revealed in the scene, separating plains from mountains from craters and describing the subcategories of each. He looks at the context of each feature and its shape, orientation, and radar brightness (light areas are rough, dark areas smooth) to determine which is a lava flow and which the tortured remains of an impact crater. Each unit and subunit is assigned a different color in his map, based on his and other scientists' current understanding of Venusian geology.

The color purple, for example, is assigned to tessera—weird, highly deformed zones where two or more sets of ridges intersect, sometimes at right angles. They were named by the Russian scientists who first observed them in radar images returned by the 1980s Venera mission and who thought the features resembled parquet floors. Their origin, says Zimbelman, is "anyone's guess."

He points to a long, thin arc of purple—actually three shades of purple—running across the bottom of the map. "When I first looked at that four years ago, it was one geologic unit," he says. "In the last year, though, I've been able to separate out areas with different histories." The light purple regions are folded belts and appear to have formed separately from the darker areas of the planet's surface. Zimbelman didn't recognize the subtle difference until he compared notes with a colleague who found the same thing in the little patch of Venus that she was working on.



This kind of collaboration is common, he says. Every year NASA brings the Venus mapmakers together for a conference—this year it was held in Buffalo, New York—where they can report on their progress and trade ideas. In the early days, a lot of the discussions had to do with naming conventions. Someone would see a particular type of feature and call it "ribbon terrain" or "undivided plains," depending on how it looked to him. "The first two years of the mapping program, that was about all we talked about," says Zimbelman. "Everybody had a different name for everything." Now there's more of a consensus



Left: Jim Zimbelman's geologic map of the Kawelu plains on Venus is based on meticulous study of Magellan radar imagery (above). Tan areas are classified as ridged plains and orange areas are volcanic plains, with arrows indicating the presumed directions of lava flow.

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on at least the major terrain types.

Marking the boundaries and contours is painstaking, hands-on work, subject to frequent revision. Zimbelman and his undergraduate intern for the summer, Martin Wong, work in pencil, making their marks on a sheet of clear Mylar overlaying the photo. "Sometimes you'll start on one corner, and by the time you get to the other end, you've realized that what you did down here has to change," says Zimbelman. Once he's satisfied that the marks are right, the Mylar goes to a "digitizing tablet" to be converted into a color digital map, which is the final product that eventually will be delivered to NASA.

Zimbelman has been at it, off and on between other projects, for five years. "I think about 80 percent of this [map] I could buy as probably being right," he says. "Four years ago I was lucky to have 20 percent."

—Tony Reichhardt



LEAH OVERSTREET

On July 20, 1999, the 30th anniversary of man's walk on the moon, Michael Collins, Neil Armstrong, and Buzz Aldrin (left to right) came to the National Air and Space Museum to accept the Langley Gold Medal, which is awarded to those who advance the science of aerodynamics and its application to aviation. Vice President Al Gore, who presented the astronauts with their medals, said that they "stand in stead with legends of flight like Wilbur and Orville Wright and Charles Lindbergh." Armstrong, speaking on behalf of his crewmates, said: "We are enormously appreciative to be asked to receive the Langley medal." Then a crowd of onlookers gave the three men a standing ovation.

MUSEUM CALENDAR

Hours The National Air and Space Museum is open from 10 a.m. to 5:30 p.m. The Museum is open every day except December 25. General admission is free.

Location The National Air and Space Museum is located on the National Mall at 7th Street and Independence Avenue SW, Washington, D.C., just west of the U.S. Capitol. The closest Metro stations are L'Enfant Plaza and Smithsonian. The Museum is currently undergoing renovation; some galleries will be closed temporarily.

Food Visitors to the National Air and Space Museum can dine at either the Flight Line Cafeteria or the Wright Place, a restaurant that offers table service to small groups. For special arrangements and group information, call (202) 371-8750.

October 14 G.E. Aviation Lecture. Chuck Yeager, who broke the sound barrier in 1947, returns for his annual lecture, in which he'll talk about his rise from an enlisted man in the U.S. Army Air Corps to a Bell X-1 test pilot at California's Edwards Air Force Base. Langley Theater, 7:30 p.m. Tickets will be available beginning September 13 through PROTIX, phone (800) 529-2440; at walk-up outlets in the Washington, D.C. area; and on the World Wide Web at www.protix.com. Tickets are free, but PROTIX charges a service fee.

October 30 Monthly Star Lecture: "The Biological Universe—Tales of Many Worlds." Steven J. Dick of the U.S. Naval Observatory will guide visitors through the 20th century debate on the existence of extraterrestrial life. November's night skies will also be viewed. Einstein Planetarium, 6 p.m.

Paul E. Garber Preservation, Restoration and Storage Facility. Get a behind-the-scenes look at the restoration workshop in Suitland, Maryland, where skilled craftsmen restore a variety of historic artifacts—everything from aircraft to satellites and missiles. Free tours Monday through Friday at 10 a.m. and Saturday and Sunday at 10 a.m. and 1 p.m. For reservations, call (202) 357-1400; TTY: (202) 357-1505.

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.



J STOLL

Keith Rosenkranz, a U.S. Air Force F-16 pilot who flew 30 combat missions during the Gulf War, is the author of *Vipers in the Storm: Diary of a Gulf War Fighter Pilot* (www.vipersinthestorm.com). On November 18, Rosenkranz will talk about his night missions at the Museum's Langley Theater at 7:30 p.m. (no tickets required).

National Air and Space Society

As a Founder Member you can help support the most significant effort in the National Air and Space Museum's history: the new Dulles Center, to be built at Washington Dulles International Airport. For information, call (202) 357-3762 or write to: The National Air and Space Society, NASM, Room 3608, MRC-310, Smithsonian Institution, Washington, DC 20560; e-mail: nass@sivm.si.edu

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Ninety Minutes

The sun is setting over Lake Powell in the Utah desert. The colors change gradually from iridescent reds and oranges high on the canyon walls to a gray mist above the water. Islands of sandstone cliffs rise from the water, beckoning explorers. I imagine flying the surrounding ridges and canyons in a small airplane, and think what a spectacular place this would be to camp in. I have chanced upon this view while looking down from an airliner.

The deserts of Earth from 200 miles high lure me in the same way. On a 16-day flight in late 1997 aboard the space shuttle *Columbia*, our crew of six made more than 250 orbits of the planet between 28 degrees south of the equator and 28 degrees north, affording us the opportunity for sightseeing on a global scale. I remember vividly the progression of water and land.

Flying east over the Atlantic, the deep green of the water lightens as we reach the African continent. The contrast between the green water and the light brown sands of the western desert is stunning. Land here looks naked and alien. The unusual ring structure of a naturally uplifted dome, Richat, lies like a whirlpool of frozen sand in the western Sahara. Farther east, the Pic Touside volcano in the Tibesti mountains of Chad rises in the desert like a marker announcing "Nile ahead." Irrigating fields along its length, the Nile meanders north, a lifeline in the stark Sahara. The rectangular irrigation patterns along the shore are easily visible in different shades of green. The ancient city of Khartoum, at the confluence of the Blue and White Niles, is the greenest city in the region. Southeast of the Tibestis, the Aorounga impact crater is harder to spot, since it lies camouflaged in the Bodele desert, striated by sands and winds for 345 million years.



NASA (4)

Continuing east, the folded ranges of the Zagros mountains in Iran look as alien as Mars. The maze of the Makran range and Harboi hills in Pakistan gives way to the magnificent Himalayas, covered with snow. To the north, the Tibetan plateau is dotted with hundreds of green lakes. We use the "bow tie" lake to start looking for Mount Everest, and the C-shaped lake, Yang-Cho Yung Hu, to declare that we have missed it. On a later orbit, we can point out Everest, especially in the early morning sun, when shadows are long and the three-dimensional effect is prominent. Abundant glaciers look like giant snow slides running down in all directions, all seeming to halt abruptly, some in translucent pools of blue ice. It is easy to see where the Brahmaputra turns south, then west, and joins the Ganges to flow to the Bay of Bengal. The delta of the Ganges is a serene mating of a river with an ocean, with a vivid contrast between wild and irrigated parts. The landmasses, islands, and shoals in the South China Sea are scattered like jewels. The barrier reef around the northeast coast of Australia looks like an emerald necklace in the noon sun.



As we orbit Earth, the colors on the surface change shades from day to night, but the sky is always pitch dark. We can easily see the atmosphere clinging to the horizon—a very thin layer, especially at sunrise, when the colors in the eastern horizon change rapidly from violets to oranges and reds. Sunsets are equally dazzling. The moon races across the sky to the western horizon just after sunset. The horizon changes from a kaleidoscope to a spellbinding silver glow in minutes.

We can't catch all of these sunrises and sunsets and moonrises and moonsets. Often, the only time we are free to float by the flight deck windows is just before or after the eight-hour sleep period. Most of the research on the ship is done in the mid-deck, where there is only one small circular window.

Twice on my flight, while everyone else is asleep, I float out of my sleep station to the mid-deck window and remove the metallic cover. An ocean dotted with atolls and shoals and rings of reefs enclosed in other ring formations moves by. I think about sailors on great ocean voyages urged onward by the unknown. About 10 minutes later, we have moved over the night side of the planet. I replace the window cover and float back to my station. The mid-deck is dimly lit by the lights of our plant growth facility. I close the door of my station and instantaneously it is pitch black. Hanging motionless in mid-air, I soon lose awareness of my orientation.

Prior to the flight, I promised myself I would look at Earth continuously for one complete orbit. The opportunity comes late in the flight. As I float at the windows in the flight deck, continents and oceans move by. South America is covered with thunderstorms as sprays of lightning shimmer through the clouds. As clouds give way, I can discern the coast and make out small settlements by their lights. Earth, a dull-black dome below us, looks alive in its display of lights. Stars hang everywhere in the sky, some clearly farther than others, hardly any twinkling. Takao Doi hands me binoculars and guides me to M42, a nebula in the Orion constellation. It looks like a faraway green castle, and our spaceship, a white chariot, seems bound for it.

An hour and a half later, we are almost back where we were. It has taken us just 90 minutes to cover the whole planet. Just 90 minutes! The realization that Earth is so small is overpowering. It almost looks like a campground, luring space explorers with colors of life. I think of the song of whales, the calls of wildlife, the trees waving their branches in winds. I feel we must search for another campground. Mars perhaps? The moons of Jupiter?

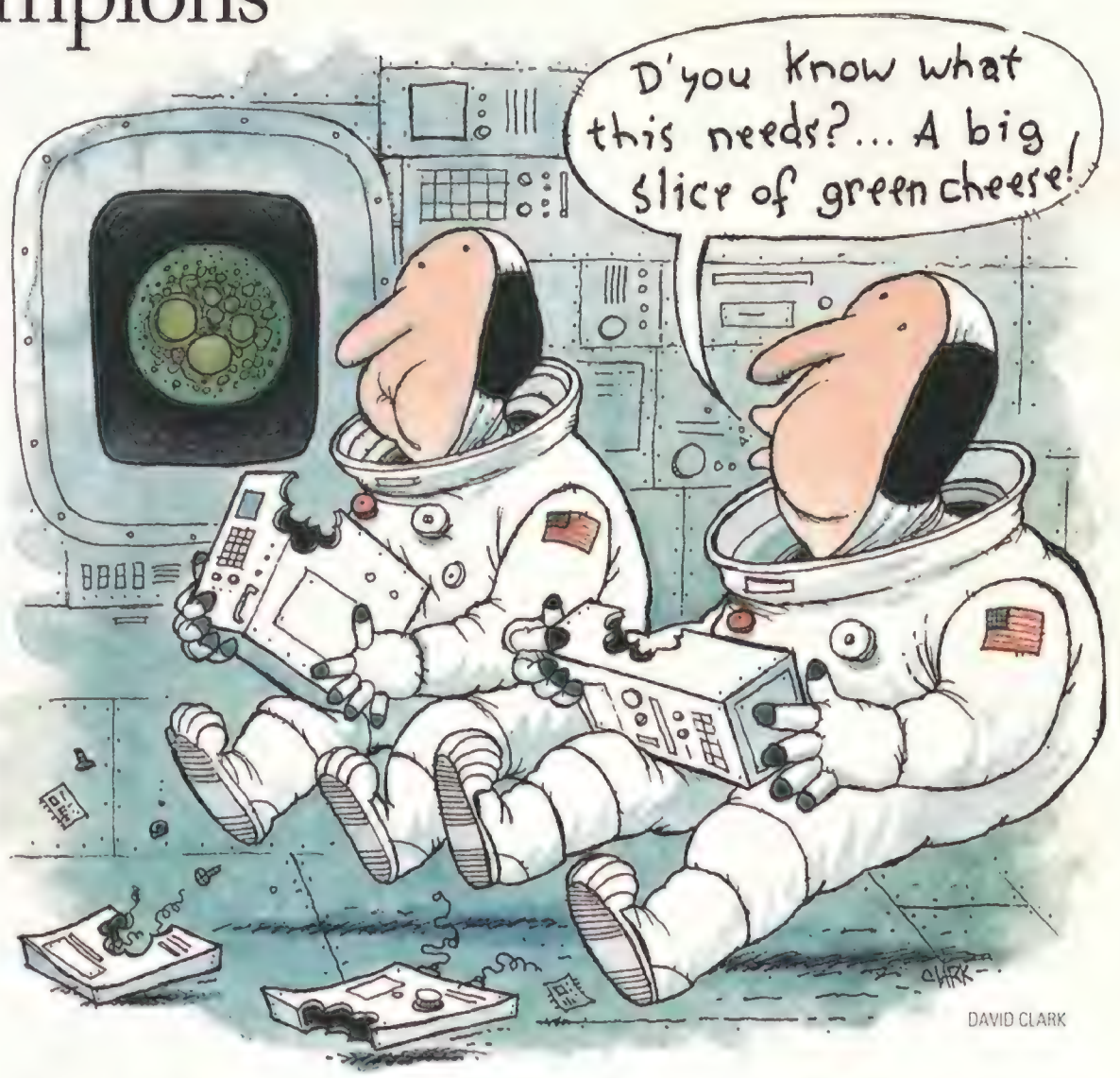
—Kalpana Chawla





Shuttle astronauts watch the world go by. In the author's words, the delta of the Ganges "is a serene mating of a river with an ocean" (opposite). The Richat structure, a dome of uplifted sediments, "lies like a whirlpool of frozen sand in the western Sahara" (top). In the Himalayas (above), the crew spotted Everest "when shadows are long" (just left of center in lower half of photo). Left: the maze of the Harboi hills in Pakistan.

Breakfast of Champions



DAVID CLARK

During a lunch break in April 1963, Sidney Schwartz of Grumman Aircraft's Human Factors System ran out to the supermarket. Normally, this would not be an unusual thing for a time-pressed engineer working on the Apollo lunar module. However, Schwartz was looking for something—and he wasn't sure exactly what it was.

What he needed was one new ingredient for a foodstuff he had conceived of for use on spaceflights. To the bewilderment of co-workers, Schwartz was developing a structural material that could double as emergency rations. He dubbed the product ESM, for Edible Structural Material. Surprisingly, the Grumman Advanced Development staff had taken an interest in the concept.

Working in Grumman's Plant 12 on the morning of that April day, Schwartz had made several trial batches using powdered milk, cornstarch, wheat flour, bran, and banana flakes, all baked in a press. The results were encouraging but not completely satisfactory. Strolling the aisles of the supermarket, Schwartz came upon something he thought would do the trick. Hominy grits was a cream-of-wheat-type cereal popular in the south, and here it was on a supermarket shelf in Bethpage, New York. The grits would add texture, just as gravel does in concrete. That afternoon he baked a new batch, using hominy in place of bran, and produced a workable, edible batch of ESM. Cost: $4.90.

The foul-smelling brew was baked at 300 degrees under 3,000 pounds of pressure. The result was a dark brown crystalline structure that looked like (and some say tasted like) Masonite. Tests proved that it could be cut, machined, drilled, and threaded. It had a hardness factor of 87—masonite's is 80. Best of all, in the weight-critical lunar module, it weighed only .04 pound per cubic inch, and provided 350 calories per 100 grams.

Grumman engineers thought ESM could be used for handles, instrument panels, lockers, clipboards, and partitions. And desperate astronauts could soak it for several hours and end up with something that tasted vaguely like a breakfast cereal with a hint of banana. Shelf life, while not studied, was thought to be quite long, and protection against moisture could be provided by a strippable plastic film. Schwartz envisioned other applications for ESM, including tables and chairs, bunks, bookshelves, and partitions in lifeboats, small aircraft, and fallout shelters.

Grumman decided to take out a patent. Searching for prior applications, attorneys could find only one patent for an edible structure: the ice cream cone.

By May, the *New York Times* got hold of the story. Fully expecting to be the subject of industry jokes, the Grumman staff was surprised that there appeared to be great interest in ESM. Both the Air Force and the Army wanted to obtain all available information, as well as samples. The Canadian airline Nordair saw a use for ESM as an emergency supply for aircraft operating in the far north.

"We made this mash that looked like dog food and molded it into boards," recalled Grumman crew systems engineer Howard Sherman in an interview in the early 1980s. But to make it structurally sound, the engineers had to compress it beyond .04 pound per square inch. Soon it became too heavy. "Besides, we all figured [the astronauts] would probably run out of oxygen and suffocate long before they ever had to eat the stuff anyway," said Sherman. "So we finally had to say no to the idea."

By the end of 1963, the edible structure idea had crumbled. Retired engineer Mike Solan remembered it fondly: "It tasted awful. We couldn't even sell it to the Marines."

—Joshua Stoff

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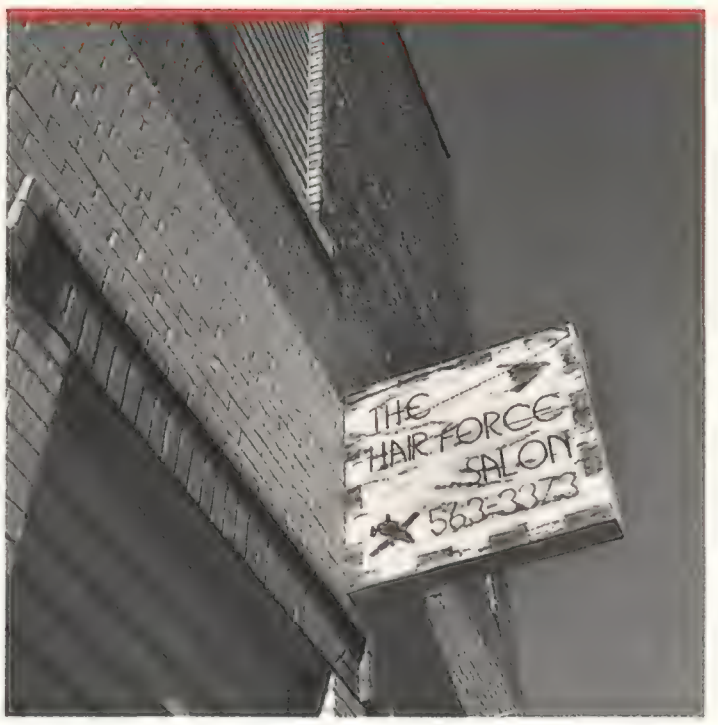
by James R. Chiles *Photographs by Mark Godfrey*



From Gerald Kimbley's ranch-style house, high on a grassy hill, Knob Noster, Missouri, looks about like any other farming community with a hardworking past and an uncertain future. Between the stately trees I can see a shuttered grain elevator, a concrete highway that shunts traffic around the downtown business district, and a cemetery.

Kimbley's family owns the Strikers sports bar at the base of the hill. He tells me it's been a struggle to compete with restaurants in Sedalia and Warrensburg, each less than a half-hour's drive away. But about this time we can hear a rumble and a roar from the east. It's a sign that Knob Noster offers at least one thing no other small town in America can boast: a permanent home for the mysterious B-2 Spirit bomber. Loaded with smart weapons and a computer disk of targeting instructions, it can take off, refuel, fly any place in the world, deal out 16 tons of destruction, and be home in time for dinner.

The flying wing rolls out of its turn over Shanghai Lil's Tattoo Parlor, crosses Highway 50, and settles into a southbound descent toward the single runway of its lair, Whiteman Air Force Base. When it's flying level, the big tail-less airplane is hard to see from the side, and it has no distinctive markings. This particular aircraft might be returning from a training mission in Kansas, or a 30-hour night bombing mission to Yugoslavia and back. The 509th Bomb Wing isn't inclined to say. The B-2 has transformed Whiteman from a sleepy base with an idle runway and nearby Minuteman missile silos that would soon be dismantled to a base with more people than ever, nearly a half-billion dollars' worth of new construction, and a task like that of no other base in the world. The subsonic B-2 is the ultimate representation of the viciously fast pace of air war today, which in the early stages can be very hostile to non-stealthy aircraft. Like the stealthy F-117 Nighthawk and B-1B Lancer, the B-2 lacks any external stores, and it can slip through even the most sophisticated air defense networks in order to attack targets.



Only subtle signs are evident in Knob Noster, Missouri, that Whiteman Air Force Base and its stealth bombers are nearby.

Overhead, B-2s fly training missions or gas up to attack targets on the other side of the globe.

When it was being conceived, the B-2 represented a deterrent—a weapon not to be used short of a global war. In 1981 the Department of Defense planned to base 132 bombers around the country, but budget cuts and a warming of cold war relationships reduced the fleet to a final total of just 21 aircraft, all of which will be based at Whiteman.

So instead of flying into doomsday with hundreds of comrades while blast shields protected their eyes from the flash of nuclear weapons, a handful of B-2 aircrews had their first taste of combat in Operation Allied Force, in which B-2s accounted for 11 percent of the bombs dropped. If B-2s were used in a more protracted conflict, the 509th Bomb Wing would likely shift some aircraft to a forward area so the pace could accelerate, but for now, Whiteman, Knob Noster, and its bucolic surroundings will remain the center of the B-2's world in both war and peace.



USAF/509 BW

Whiteman hosts other killing machines, though none quite as evil-looking as the batplane. Lieutenant Colonel Bill Dawson of the Missouri Army National Guard's First Attack Battalion has an intimate view of the neighborhood from the cockpit of his AH-1F Cobra. His unit, which has 24 helicopters, arrived in 1973, and is in line to receive AH-64 Apaches. On a Friday in December we flew low over farm fields and grain silos because, as Dawson explained, that's what Cobras do in combat. "We like to see what we're shooting at," he says.

"Show him that we're real pilots, not systems managers," a fellow helo driver joshed Dawson as we left the battalion

headquarters. He didn't have to nod at the row of B-2 buildings next door for me to know where the barb was aimed. The AH-1F, a narrow-body, two-seat gunship that carries guided missiles, rockets, and a 20-millimeter gun into battle, is an old-fashioned, unprogrammed, gloves-on machine. We're in one of the oldest airframe in the battalion, number 15306, built in 1966 and flown in Vietnam before some of the 1st Attack Battalion's pilots were born.

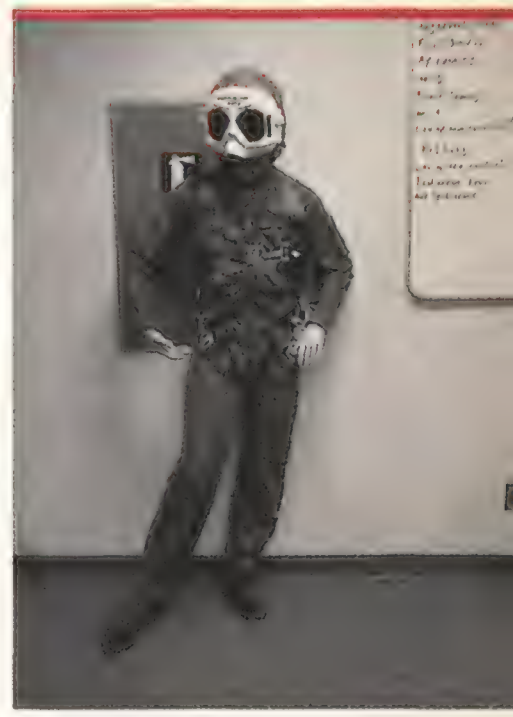
After we walked out to the flightline, Dawson ran up the single turbine, completed the preflight checks, and was satisfied. "These are unbelievably reliable," he told me over the intercom. "If we can get a ship off the ground at Whiteman, it's usually good for the day."

As we lifted off, the helicopter banked and I got a better view of a row of light gray A-10 "Warthog" tank killers belonging to the Air Force Reserve's 442nd Fighter Wing, which occupies a set of buildings on the west side of the ramp, opposite the B-2 area. The 442nd moved here in 1994, shortly before the B-2 became operational.

We rose into the clear, chilly sky and turned north. West of the flightline were static displays of other odd couples from Whiteman's past: the B-47 Stratojet bomber and the Huey helicopter. Beyond was Ike Skelton Park, named after the Missouri congressman who might be considered a patron saint of military programs in general and central Missouri Army and Air Force bases in particular. Now that Representative Ron Dellums has retired, Skelton is the ranking Democrat on the House Security Committee. For as long as he stays in Congress, central Missouri's remaining bases are likely to hold out against pressures for more consolidation.

The town of Knob Noster lies on the north side of Whiteman; once base and town were separated by farm fields, but now a wooded subdivision butts up against the base's perimeter fence. The town's most distinctive feature from this perspective is its hills, or "knobs," as Missourians call them.

We flew west for five miles, passing over fog-shrouded scars of abandoned coal strip mines. On the horizon was the university town of Warrensburg, the closest sizable city to Whiteman and a popular spot for off-base housing. We turned south toward the Guard's low-level training area. It's on Army Corps of Engineers land around the fringe of Truman Lake, a big reservoir. Dawson made a tight circle over a marshy field near a set of power lines, then settled toward the ground. The Cobra halted eight feet above Earth, and as Dawson nudged the helicopter under the power lines, fragments of dry brown grass blossomed upward in the rotorwash. He explained that his pilots



Each B-2 gets pampered in its own hangar (top), coming out only to fly.

A mannequin sports a nuclear blast shield, a symbol of the B-2's intended role as a world war weapon—quite different from its debut over Kosovo.



Whiteman is home to an eclectic flock, including stick-and-rudder A-10A "Warthogs" of the Air Force Reserve and Army National Guard AH-1F Cobra attack helicopters (right).

A B-29 inside Whiteman's main gate reminds visitors that the 509th Bomb Group—then the 509th Composite Group—dropped atomic bombs on Japan during World War II.

occasionally give rides to A-10 and B-2 pilots so they can see the battlefield at Cobra-level—in other words, how it really looks. "Whiteman has strategic, operations, and tactical aircraft—the full spectrum of warfare," Dawson said over the intercom. "All our skies are the same color but we work in different worlds."

On the way back to the base, Dawson directed my attention to a defunct missile silo, which stood out as a fenced square of brown among the green fields. For almost 30 years, Whiteman's 351st Missile Wing oversaw 150 silos like these scattered across central Missouri, each holding a nuclear-tipped Minuteman II missile. Not one of the 351st Wing's silos remains intact, all having been destroyed by explosives under the Strategic Arms Reduction Treaty. Dawson said the Cobra pilots liked having the silos around because the fenced enclosures made good landing pads in the event of engine trouble, and stomping on the launch door always roused a security patrol from the base. Under the arms treaty the United States was allowed to keep one disarmed Minuteman II silo and one control center for historical purposes. Whiteman happened to have an underground launch control facility located within the base fences, and so won the distinction of keeping the sole surviving center, which remains open for tours. Perhaps someday there will be a similar exhibit of B-2s and their equipment, a relic from the days of manned bombers.



As we dropped toward Whiteman, I checked out the B-2 hangars, which are called "docks," from above. All the doors were closed and, except for the Warthogs and Cobras on the margins, no aircraft were in sight, giving the base a strange, unpopulated look. Or perhaps it's the world's most elaborate practical joke—stealth bombers really are invisible. Actually, Whiteman's desolate appearance is typical; the docks are designed to host everything a B-2 needs from repair to bomb loading, behind closed doors. When a Spirit is ready to go, the doors open, it taxis out, and the secrecy continues—because the B-2 carries nothing on wing pylons, such as cumbersome long-range fuel tanks or clusters of weapons. No casual observer, whether strolling to the commissary on base or atop a tractor in an adjacent field, can tell





Top: A change-of-command ceremony takes place under a Spirit's gaze; the stealthy bombers are tickets to high-visibility careers. But the 509th is picky about who gets to fly—many pilots stay outside the gate, along with everybody else without clearance.

by the B-2's appearance whether it is leaving for a practice flight over Kansas or a transoceanic attack.

Still, the local people probably know more about the workings of the base than what comes out in Whiteman press releases. It's unavoidable when half the town's adult population is active-duty or retired Air Force. Two men I talked to claimed that by noting the time of takeoff and the sound of the engines, they could tell whether a B-2 was fully loaded and headed for Yugoslavia. Through their churches—but not from the 509th Bomb Wing, which kept the names of pilots flying combat missions secret—Knob Nosterians knew which men were in harm's way. During the conflict the town offered quiet support, not banners or rallies, for the aircrews.

"We're kind of going along, business as usual," city librarian Julie Caldwell said when I asked her about the low-key attitude. "We put an awful lot of faith in the Air Force and the machinery out there."

Even before the Spirits began to arrive at the base, Knob Noster had long ridden the ups and downs of having a military base next door. The base got its name from George Whiteman, a resident who as a 22-year-old second lieutenant was shot down on December 7, 1941, while getting his P-40 off the runway at Bellows Air Field on Oahu.

I met George's brother Gene after a memorial service for war veterans in the Sedalia cemetery. He remembered riding out to the site of the future base in his father's sedan when he was 12 years old, shortly after his brother was killed at Pearl Harbor and the area was no more than hayfields and crop rows. His father had gotten a job as a carpenter assigned to the base's construction. What opened in 1942 as the Sedalia Glider Base was among hundreds of nondescript transit and training bases thrown up around the country for the burgeoning war effort. Within months, the base was training glider crews for landings in Normandy and Sicily. The federal government abandoned the facility at war's end, then reopened it in 1951 as a Strategic Air Command base.

Ten years later the Air Force picked the base, now renamed for George Whiteman, to host the 351st Missile Wing. Boeing and its subcontractors began a crash program to build 150 silos and 15 underground control centers and lay 1,770 miles of cable. The whole complex took two years and two months to build.

"It was chaos to no end," says Bob Carr, 75. Carr, who is descended from the family that opened Knob Noster's first grocery store in 1888, was city clerk during the missile boom. Workers on the base pre-assembled giant cages for reinforcing the underground control sites, then trucked the cages to the sites. He is still rankled by the memory of one oversized truckload of rebar



Like many of her colleagues, retired Master Sergeant Marion Crutchfield (above) left the Air Force but not Knob Noster—she's now the mayor.

Because of the celebrity airplane, life at the base includes frequent media visits.

blundering through town against orders, tearing down strings of Christmas lights hung all along the main street. "Knob Noster used to be a doormat for the base," Carr said. "They wiped their feet on us. Then when I was mayor, Knob Noster was hometown for them."

With all the bother of the missile silo construction, he said, one advantage for the town after it was done was that "the missile people were here forever. Now the Air Force people are up and gone," he said.

"There's a different feel now," Caldwell told me. "Two or three years and they're gone. They don't get a chance to become a part of the community like before. Some Minuteman people were here eight to 12 years, so they became involved."

And the Air Force people are more scattered across the landscape than before. "The missile people weren't party types," Carr said. "They spent long hours away from their families, so they liked to live nearby. And during the B-47 days even Warrensburg was considered off limits. Now most of the people from Whiteman live in Warrensburg and Sedalia. Warrensburg is a college town, so it has girls there."

Today, Marion Crutchfield is the mayor of Knob Noster. A Newport, Rhode Island native, Crutchfield retired from the Air Force after 24 years, and was a first sergeant for the missile wing when she left. She has a cozy office in the city hall on State Street but gets the best view of how her city is doing from her worktable at the Just Nails salon, where she is a manicurist. Out the front window she can see all the traffic on McPherson Street. It's quieter now, since the Air Force built a highway bypass on the west side to run base traffic around the city to its main entrance, better known as the Spirit Gate. A big part of the mayor's job is to support anything that brings people and business to the city. She also presides over the town's big annual events, the Fall Festival and the Miss Knob Noster Pageant. She hosts a ribbon cutting ceremony for each new business opening in town.

I asked Crutchfield how the town came to have so many Air Force retirees. "It just kinda grows on you," she said, "and we still have full use of the facilities at the base." Six city officials, including the chief of police, are retired Air Force.

And while things aren't the same as they were during the days when the missile wing was at Whiteman, any rural city with otherwise dwindling economic prospects would welcome the benefits of having an internationally known base next door that is still receiving new aircraft. "Without the base, Knob would have dried up," Julie Caldwell said simply.

A new bomber arrives every few months, each commissioned with a state's name, like a flying battleship. While I was visiting the base in May, the *Spirit of Indiana* arrived after a celebratory stopover in Indianapolis.

A group of invited well-wishers were on hand to greet the arrival. There were off-duty pilots and enlisted men, their families, and local elected officials. As the airplane approached, the order came to secure all hats—a precaution to keep unwanted things from flying into the four engines' intakes.

Like its fellow Spirits, the *Indiana's* nose has a sort of sparrow-like profile, with a slightly downturned point reminiscent of a beak. It bears a light gray heraldic emblem on its upper hull, reading "Defensor Vindex"—Latin for Defender Avenger—a reference to the original intent of the aircraft. As the ground crew secures the plane, a ladder folds down. 509th Bomb Wing commander Brigadier General Leroy Barnidge Jr. and his copilot climb out and wave.

Barnidge goes to the microphone and gives a brief talk that positively bubbles with enthusiasm about the smooth pace of the B-2's combat deployment over Yugoslavia and its contributions to the





Above: With the B-2 hangars, or "docks," in the background, an A-10 pilot from the Air Force Reserve's 442nd Fighter Wing returns from a training mission.

A parachute and other survival gear form abstract festoons in a 509th aircrew training room.

bombing campaign; he praises the local people for their support. Predictably there is no mention of the mistaken bombing of the Chinese embassy in Belgrade; after all, the crew on that mission flew 6,000 miles and hit the exact spot mission planners told them to hit.

Now it's time for the "swacking." The crowd gathers in a blue and white party tent, and Barnidge's copilot raises a gleaming ceremonial saber that a retired pilots' association once gave to the wing. He cleaves a slab of white cake with a single blow. At Barnidge's urging, the crowd repeats the chant engraved on the blade:

Silent thunder
The Beast stalks its prey
The Spirit is upon them...
Yee haw, bombs away!

The visitors cheer, but the chant has a slightly forced quality, perhaps because the B-2 is unbloodied and so new to combat. Being a stealthy airplane, the Spirit is not a battlewagon of the "12 O'Clock High," flaming guns variety, like the four-engine heavies once flown by the two squadrons that make up the 509th Bomb Wing. The B-2 carries no defensive missiles or guns. The Air Force also has been cautious in deploying the airplanes in combat. It was only after Navy cruise missiles and B-52s, flying outside the range of Serbian gunners, attacked that the B-2s were sent to their targets. While declining to go into details about how the strikes went, Barnidge told the press afterward: "We measure our misses with a yardstick."

The 509th Bomb Wing is composed of two bomb squadrons, each of which will eventually have 10 bombers. In 1945 the 393rd Squadron flew B-29s for the 509th Composite Group, the only unit in the world ever to trigger nuclear weapons in wartime.

The 325th Squadron fought in World War II under the 92nd Bombardment Group, which called itself "Fame's Favored Few." The 325th flew its B-17s through the strongest of Hitler's defenses. Flying among the lead planes in a massive raid on the Schweinfurt ball bearing plants on October 14, 1943, the squadron lost every airplane it put in the air that day, leaving only one of the squadron's flying officers alive and uncaptured. But the 325th rebuilt. Among the 300 missions flown by war's end, the unit successfully fired rocket-powered missiles against submarine pens at Limuiden. The two squadrons' paths first crossed in 1968 when they both operated B-52s in "Arc Light" carpet-bombing missions over Vietnam.

Barnidge is one of the few pilots in the 509th Bomb Wing old enough to have flown in Vietnam, where he served as a forward air controller. More typical is a young major I met before Operation Allied Force. Because the Air Force is still operating under security regulations that ask the press not to identify individual pilots, I'll identify him only by Acorn, which is a variation on his radio call sign.

Acorn was a B-52H pilot at Carswell Air Force Base in Texas. For one full week every month, 24 hours a day, until October 1992, when U.S. nuclear forces stood down, his six-man crew had to remain at the base on alert duty, with their bomber loaded,







A B-2 pilot (top) holds an optical disk used to load mission profiles into the B-2's navigational systems before flight.

The Oscar-1 launch facility at Whiteman once controlled 10 nuclear-tipped missiles; now it's a historical display.

fueled, and ready to go. "I was tied to that plane," he said.

Now it's closer to a regular job. Not only are pilots free to live off base, but even commanding officers are. Acorn lives on base with his wife and two-year-old son in family housing, but many of the pilots do not. One housing subdivision in Warrensburg holds so many B-2 crew members that the pilots call it Stealth Ridge.

Acorn, age 36 and born in Puerto Rico, is rated as a mission commander, which is the senior of the two B-2 crew positions. On the day we met, Acorn had been out flying the B-2 on a training flight until three in the morning, but he was still eager to talk about his work and how he got here.

We got off a bus at Dock Six, which is home to the *Spirit of Arizona*. Almost as wide as a football field is long, each of the 14 docks is built to hold one bomber. By using every hangar, including the wash rack and paint shop, all 21 Spirits can be kept indoors.

The painted concrete floor under the *Arizona* is shiny and features small metal doors concealing hose connections for vital fluids. It's a sterile environment—no puddles or even steel pans for dripping fluids are in sight.

A narrow folding ladderway leads up to a hatch in the *Arizona*'s smoothly curving underside, like steps into a flying saucer. Acorn leads me up through the narrow tunnel and we emerge into a dark compartment about the same size as the cab of a tractor trailer rig. The interior is a dull, flat gray, and it's difficult to see much of the instrument panel, because the airplane is not powered up.

Unlike the interiors of most other military aircraft, which give off a telltale aroma made up partly of sweat, hydraulic fluid, and paint, the B-2 smells like a new car. Built into the bulkhead behind the left seat is a device to make hot water for coffee or soup, or to heat up the hot-dog-and-chili combination the pilots call bomber dogs. There is a portable toilet concealed under a seat cover and a cubical space in the rear of the cockpit big enough for two duffle bags. When the access ladder is folded up and stowed, it creates a spot on the floor just big enough to lie down during a 30-hour round-trip flight from Missouri to Kosovo. For long flights, pilots take along a sleeping bag and a cooler. Simple things, said Acorn, mean a lot when you're trying to stay alert on a long flight: a change of clothes, a towelette bath, catnaps alternating with longer sleep periods. During such missions, most of the flight proceeds by computer direction and only one pilot needs to be at the controls.

Acorn climbed into the right seat, motioned me into the left, and flipped down a metal frame behind the pilots' floor console. "Here's our Coke can holder," he said. Acorn's first task when starting a mission is to make his nest, which involves unpacking the contents of his bag and plugging in the optical disk that contains the elaborate flight profile. This is prepared by members of the Mission Planning Cell, who begin their work 24 hours before takeoff in a secure underground vault at Whiteman.

If the heart of the Spirit is its set of onboard computers, its optical disk drive is its deadly intent. In wartime the computerized profile holds a route for each B-2 to sneak through weak points in the enemy's radar fence and arrive at the proper point for bombing. Mission planners call this sinuous path the Blue Line. The Air Force doesn't claim that the B-2 is invisible to radar; however, the Spirit's radar reflection on a well-plotted evasive course is so faint that air defense radar can't continually track the aircraft through the confusion inherent in today's electronic battlefield.

Acorn thinks the Beast is a beauty of a plane. "The way all systems integrate to fly long-endurance and stealth missions—that makes it a weapon I love to fly," he said.

And he relishes the wide experience brought to the wing by other pilots. The Wing has men with thousands of hours in combat aircraft, including the F-4, F-15, B-52, F-117, FB-111, and B-1. "We're all basically the same," Acorn said. "We have the same background and the same rank. Most have a wife and two kids, and we make the same amount of money." In an Air

Force that is increasingly hurting for pilots of all kinds, the 509th Bomb Wing has no trouble getting applicants for its ranks.

"We don't take just anybody," Barnidge says. "This is a one-billion-dollar-plus airplane, so the last thing we need is someone who can't think on his feet." In a recent round of selection, the 509th had 48 applicants for one-third as many slots. It's possible to come into the squadron and earn a slot as mission commander without passing through the pilot rating first. Barnidge said such applicants should be top-ranked fighter or bomber pilots "with tons of experience and a past life." Pilots can work out their tactics in the simulators, where they can take risks discouraged in everyday training (such as nap-of-the-earth flying) and experience the kind of "furballs," or aerial battles, offered on today's electronic battlefield.

The wing also needs pilots who are diplomats. The 509th sees a steady stream of bigwigs and reporters, and sometimes no public affairs officer is around to intercept the questions, as when a dignitary wins permission to go on a short demo flight. Because the B-2 has only two ejection seats, no third person can ride along. At the end of the trip he or she receives a small medallion, given only to those who have flown in the famous Stealth bomber. Acorn carries his at all times; one side has a star formed by the noses of five B-2 silhouettes pointed inward. The number 153 is pressed into the face, and a tiny "79" on the rim. It signifies that Acorn is the 153rd person to fly on the B-2, and the 79th rated crew member.

During my last visit to Knob Noster, the high school auditorium hosted the Class of 1999's graduation ceremony. Outside on a lovely May evening, the parking lot was filled with pickup trucks and sedans, many with white-painted messages on the rear windows reading "We're Outta Here" and "Stick Me With a Fork, I'm Done." Inside, the black-robed seniors held small bibles they had been given and listened to speeches and prayers about the road ahead for them.

Just over the hill another commencement was under way, as the planning cell at Whiteman packaged its intelligence briefings to go to war half a world away. The hangar doors would open soon, and the B-2s would taxi without fanfare and climb above the checkered farm fields. Below, it's business as usual at the library, tattoo parlor, and the Hair Force salon. The celebrating seniors scarcely look up.



A mixed bag of B-2s, A-10s, and AH-1Fs share the roomy ramp at Whiteman. It's a rare scene: Spirits are reclusive, and often stay behind closed hangar doors.

disturbance of as much as 2°
round level in this vicinity.

Magnetic disturbance of as much as 4°
exists at sea level in this vicinity.

CAUTION
LASER LIGHT ACTIVITY
See Airport/Facility Directory

CTC BAY APP WITHIN
20 NM ON 135.1 307.2

GOLDEN GATE BRIDGE

SAN FRANCISCO

LAKE MERCED

HUNTERS POINT

SUTRO

Presidio

Point Bonita

GOBBS

SEEMS

Pacifica

Rockaway Beach

Pt San Pedro

Pedro Valley

Montara

Moss Beach

HALF MOON BAY (HAF)
67 °L 50 122.8
RP 30

Ft Granada

CRYSTAL SPRINGS CAUSEWAY

satellite dish
Pillar Point

Half Moon Bay

bldgs

warehouse

stadium

large cross

crane

cranes

SFO 15 NM

SFO 10 NM

SFO 5 NM

SFO 230°

SFO 200°

V 150

V 25-150-198

757

876
(853)
bldgs

259
(248)
cranes

602
(539)

859
(809)
bldgs

1811
(977)

451
(400)

311
(300)
stack

940

393
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(460)

313
(300)

1489
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1898

1944

1075

517

30

14

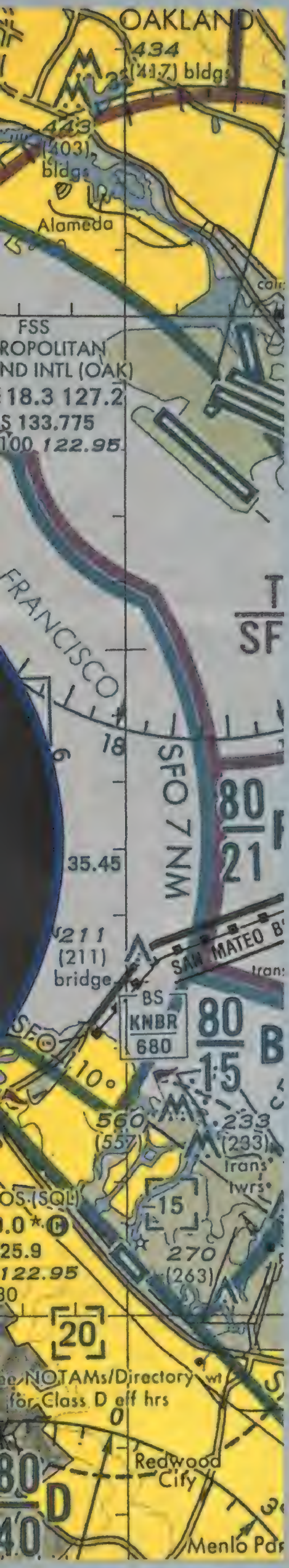
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T 15



THE ART OF THE CHART

Somewhere in those symbols, lines, and colors is all the information you need to fly from here to there.

by Stephan Wilkinson

I have in my airplane a microchip miracle: a small, expensive, ever-changing, dead-on accurate, utterly magical moving-map cockpit display. Driven by an assemblage of silicon powerful enough to run Rhode Island—well, at least to operate all its traffic lights—the unit sniffs data sent to it by Global Positioning System satellites. It instantly and continuously does the arithmetic necessary to say to me at all times, "Here you are, dummy, right where the little airplane symbol on the map is."

See the little mock-Cessna chugging along over highways, rivers, and radio beacons? See the screen display zoom out to show it crossing all of North America at an imperceptible rate? And then zoom in to make it herky-jerk at 200 mph across my hometown streets? That's what aeronautical charts have come to: green and black pixels on a screen the size of a playing card, doing their best to approximate the basic outlines of the world below.

Frankly, I prefer the old-fashioned way. It uses paper, ink, art, artisanship, and nearly a million tints to produce what pilots call sectional charts.

Sectionals don't need batteries. They won't break if you drop them. They never flash a red light and announce "WARNING: SIGNAL LOST!" They can be consulted on the kitchen table or in the bathroom. And they cost only $7.25 apiece.

Aeronautical charts are based on geological survey maps, upon which are superimposed some 50 layers of terrain and navigational information. Photography by NOAA verifies that all is precisely depicted at, for example, San Francisco International Airport (inset).

Since 1927, pilots have navigated U.S. skies by using paper charts produced by what is today called the Office of Aeronautical Charting and Cartography (AC&C), part of the National Oceanic and Atmospheric Administration and thus a ward of the Department of Commerce. Sectionals began as strip maps showing the landmarks and terrain between basic destinations, the very first of them Moline, Illinois, and Kansas City, Missouri.

In those days, landmarks were roads, rivers, railroads, towns, fairgrounds, and the occasional lighted beacon, and the pace was slow enough that the charts were accompanied by text descriptions of the route, sometimes on the other side of the chart. "People would fly and take notes for the pilots who'd be coming along behind them," says Christo Cambetes, a NOAA staff cartographer.

Today, raging civilization has built cell phone towers, drag strips, domed stadia, airports, dams, skyscrapers, race tracks, power lines, many-spired Mormon temples, parachuting sites, Disneylands, radio astronomy antennas,



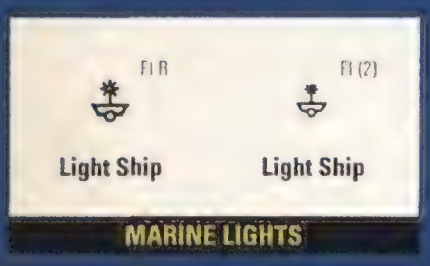
NATIONAL SECURITY AREA



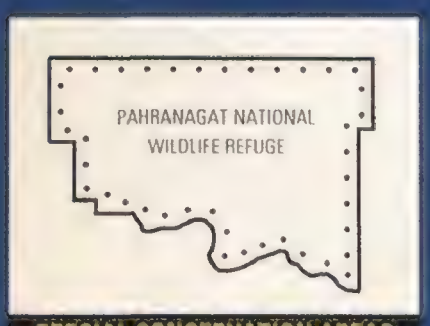
HIGH ENERGY RADIATION AREAS



RESERVOIRS



MARINE LIGHTS



SPECIAL CONSERVATION AREAS



MISCELLANEOUS AIRSPACE AREAS



VFR CHECK POINTS



tank farms, ski lifts, power plants, and a hundred other "cultural features." Today, they're all included on sectionals. Says Terry Laydon, director of the AC&C, "The FAA comes up with the [general] concepts and features to be depicted on the charts, but we develop the standards and then work out the issues—what should be depicted and how it should be presented to the pilot."

"The standards" have been collected in an inch-thick volume that spells out everything from how to depict a kanat (an underground aqueduct with surface air vents) to the symbols for "populated places in ruins," the difference between *wadis* and *sebkhas* in a desert, and when a rock that is "bare or awash" is big enough to be shown as a tiny island. Read it and you'll understand why AC&C map-makers all have degrees in cartography: There are 147 symbols for topographical and cultural information alone, with nearly 100 more for purely aeronautical features, and each is specified right down to type face and size, color, and line thickness. And what the cartographers must constantly keep in mind is that all this information has to be made crystal clear to a pilot reading a chart with one hand and flying an airplane with the other.

In 1927, there was no piece of sky that was off limits to aviators. Today, everywhere you look there is airspace that is for one reason or another forbidden to pilots who fly by eye and choose not to have their routing defined by radio and air traffic controllers. There are also no-excuses, absolute-exclusion prohibited areas, the airspace above the White House perhaps the best known of them. There are military restricted areas where practicing dogfighters don't want to run into a Bonanza. There are air defense zones where, if you enter without notice, it's assumed you're a terrorist. There are vast blocks of restricted airspace over many big cities to provide freedom for airliners to maneuver during arrival and departure. There are routes where bombers practice very-low-altitude missions—not strictly forbidden airspace, but you're warned that you might be sharing it with a B-52 on fast-forward down in the weeds. Sectionals show all of these as well.

A typical sectional makes a Manhattan road map look like the scrawled directions to your friend's Fourth of July barbecue. "Yes, chart clutter absolutely is a problem," admits Ronald Bolton, the chief of the AC&C's Aeronautical Chart Division, the group that compiles and

THE ANNOTATED SE



LOS ANGELES SECTIONAL AERONAUTICAL CHART SCALE 1:500,000



GRAND CANYON VFR AERONAUTICAL CHART SCALE 1:250,000

1: Concentrated glider activity in this area.

2: Blue type designates Class B airspace within solid blue lines. Class B airspace encompasses major airports that use radar to track all traffic. Aircraft must have a transponder that transmits aircraft altitude and ground speed to the radar. Pilots must obtain a clearance from Approach Control before entering Class B airspace.

3: Airport information: Los Angeles International Airport (three-letter ID: LAX). Control tower frequencies: 120.95, 133.9 MHz. Tune to 133.8 for recorded landing information—ceiling, visibility, barometer setting, wind speed and direction, runways in use. Airport elevation is 126 feet above sea level. Longest runway is 12,100 feet Airport administrative frequency is 122.95. Airport layout is four parallel runways.

4: Indicates Class C airspace within solid magenta lines. Class C encompasses control-tower airports that provide limited radar traffic advisories. Aircraft must have a transponder. Establish radio contact with Air Traffic Control before entering airspace.

5: Blue dotted-line circle denotes Class D airspace, which encompasses control-tower airports that are not equipped with radar. Obtain clearance from control tower to enter. Airspace ceiling is 2,500 feet.

6: VOR compass rose. A navigational aid, the Very High Frequency Omnirange radiates signals through 360 degrees. The "spokes," or radials, are used to determine position.

7: Santa Catalina VOR broadcasts on 111.4. Military aircraft use TACAN channel 51. Three-letter VOR ID is SXC. Morse code is displayed.

1: Denotes special conservation area (Saddle Mountain Wilderness Area).

2: The Maximum Elevation Figure (here, 9,600 feet) states the highest terrain or obstacle within a box comprising 30 minutes of latitude and 30 minutes of longitude.

3: Denotes a Low-Altitude Enroute Airway (V indicates below 18,000 feet), an air route based on a VOR radial. There are 104 miles between navigational aids on this segment of air route Victor 257.

4: Isogonic line indicates "variation," the number of degrees of difference between the True North Pole and the Magnetic North Pole. Aircraft compasses point to Magnetic North. In this area, pilots must subtract 13 degrees from their true course to get their magnetic course.

5: Lookout tower (base of tower elevation 9,165 feet).

6: Critical Noise-Sensitive Area (Point Imperial).

7: Visual check point, a position-reporting marker; here, a prominent geological formation (Temple Butte), with Global Positioning Satellite system latitude and longitude co-ordinates noted.

8: Railroad track

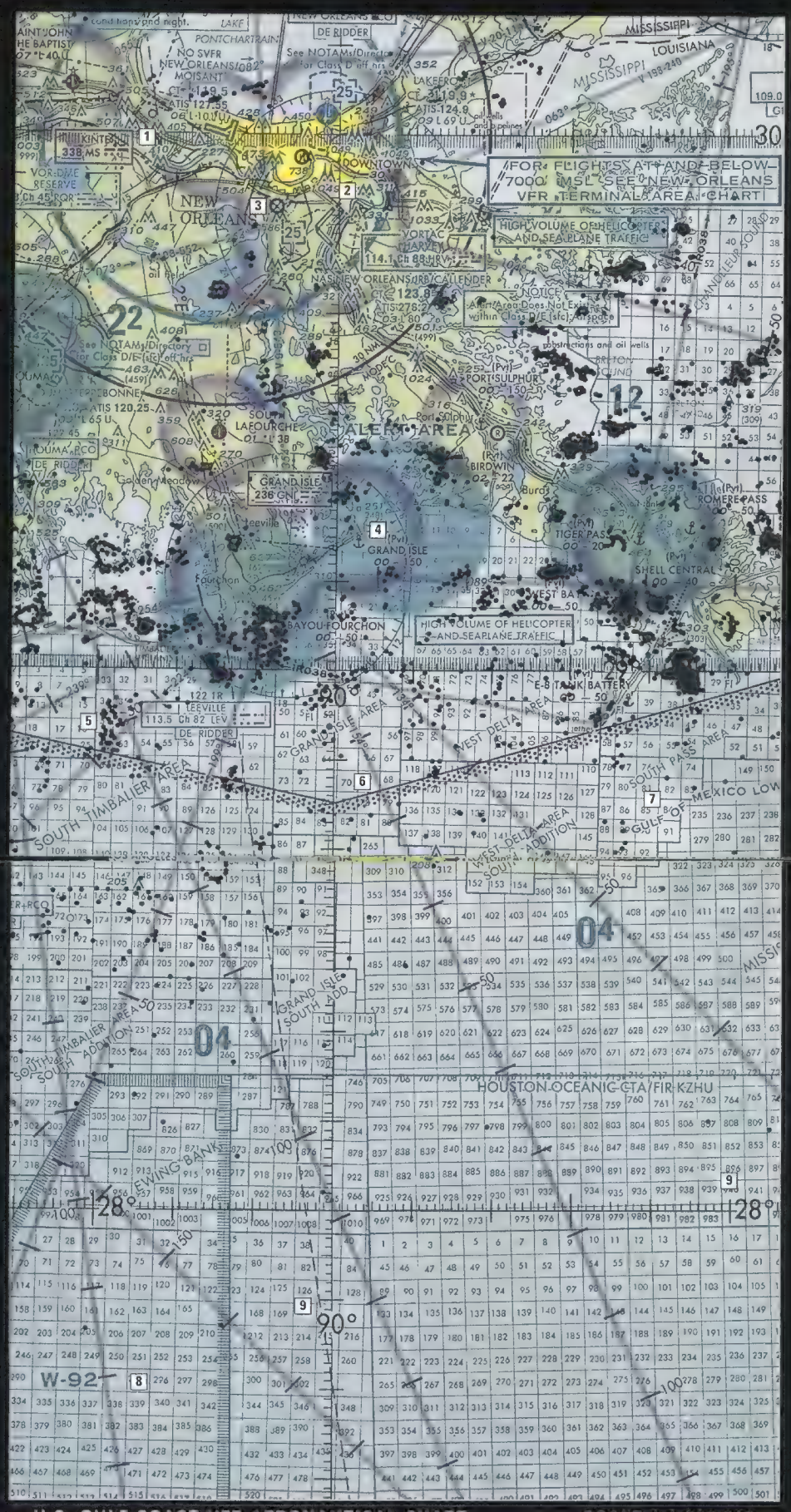
9: Special Airspace Area (noise-sensitive Grand Canyon National Park).

A supplement to the October/November 1999 issue of *Air & Space/Smithsonian*.
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ECTIONAL

How to read an air navigation sectional chart.

AIR&SPACE
Smithsonian



U.S. GULF COAST VFR AERONAUTICAL CHART — SCALE 1:1,000,000



NEW YORK HELICOPTER ROUTE CHART — SCALE 1:125,000

KINTER 338 MS

1: Non-Directional Radio Beacon, a navigation aid. An Automatic Direction Finder in the cockpit indicates the direction from which the signals are being received. Kinter NDB broadcasts on a frequency of 338 kHz.

1049

2: Left, obstruction under 1,000 feet. Right, obstruction 1,000 feet tall or higher (1,049 feet).

3: Abandoned paved runway. Use only as landmark.

4: Seaplane base.

5: Each dot represents an oil platform, the location of which is provided by the U.S. Coast Guard.

6: Air Defense Identification Zone. All aircraft entering domestic U.S. airspace must provide identification before entering. Violators will be intercepted by government aircraft.

82
SOUTH PASS AREA

7: Oil lease block number and named area provided by Bureau of Land Management. The Gulf Coast chart is designed primarily for helicopter traffic to oil platforms.

W-92

8: Warning area W-92 ("FL 400 0700-2400 ZHU CTR" elsewhere on the chart indicates that the special use airspace extends to 40,000 feet, operates from 7 a.m. to midnight, and is controlled by Houston Center).

28°
90°

9: Latitude and longitude (90 degrees west and 28 degrees north).

1: Left, public or private heliport. Center, hospital helipad. Right, trauma center.

GEORGE'S RESTAURANT
WORLD TRADE CENTER

2: Prominent landmarks. Nearly all helicopters in a large city fly at low altitude. For navigational purposes, landmarks are more useful than radio navigation aids.

3: Racetrack (prominent landmark).

4: Tanks (water or gas).

HUDSON RIVER

5: Primary helicopter route and name. Arrow indicates one-way direction. The northbound Hudson River route: "East side of Verrazano Bridge to Governors Island direct World Trade Center via east bank to Harlem River."

278

6: Interstate highway.

70/15 70/SFC

7: Floor and ceiling of Class B airspace in these areas. Left, floor 1,500 feet, ceiling 7,000 feet; right, floor is surface, ceiling, 7,000 feet.

VERRAZANO BRIDGE

8: Flag indicates Visual Check Point landmark. Used to announce location to Air Traffic Control.





Dodge Different.

continually corrects sectionals. "These are the most complex charts I've ever worked with, and I've been doing this since 1974. We make the best damn charts in the world, and we spend more money checking and verifying them than we do in actually producing and printing them. It's a very accurate product."

I have flown with charts and without—the without largely the consequence of carelessness or overconfidence. But just as those who've been rich and poor say rich is better, I say charts is better. One night, a friend dropped me off at a maintenance shop in New England to pick up my airplane, and sailed away into the starry dark before I realized that I'd forgotten my sectional.

Never mind, this is home territory, I thought. For 33 years I'd criss-crossed the cities and rivers and highways around my home in the Hudson River Valley. *Hell, I'll just fly west till I hit the Hudson.*

Let me tell you how lonely it feels to be a mote in the sky, suspended above a vast sea of lights—and, worse, areas of utter blackness—with an increasing awareness that you haven't the faintest idea where you are. Had the Hudson River already passed beneath me? Was that city Hartford, or was it Albany? I couldn't pull over and ask directions unless I chanced to see the beacon of an airport. Without my sectional I was a blind person with a 200-mph cane, tap-tap-tapping across the airspace and relying on memory.

I once flew with a bush pilot in the northern Arctic—indeed, we were on our way to the north magnetic pole, and, magnetic compass useless, he kept track of our grumbling old de Havilland Otter's progress with his thumb on a chart that he held in the same hand that held the yoke. He moved thumb and fingers as though he was saying a very slow rosary. Otters don't go very fast, but if he'd dropped the near-featureless map and lost his place, we might as well have landed, parked, and waited for the Mounties to find us.

Charts are security. Charts are essential. Even a cockpit filled with computers doesn't substitute for a map. Some months ago, riding in the jumpseat of an SAS 757 from Oslo to Newark, New Jersey, I was amused to notice that the first officer, sitting behind navi-





Cartographers have created some 250 symbols to depict topographical, cultural, and aeronautical features (opposite, far left). The NOAA Flight Edit staff takes aerial photos to verify changes in terrain, landmarks, or obstacles for the cartographers (right and top).



gation displays the size of small television sets, not only kept track of our progress on a paper chart but had outlined the route with a yellow highlighter.

In his Washington, D.C. office, cartographer Cambetes picks up a folded sectional and says, "This is a tool." He whacks it again and again against a steel partition. "Now may I do that with your fancy handheld GPS receiver, please? GPS is also a tool, but don't leave the sectional out of your toolbox because of it."

Sectional charts are often taken for granted, yet they are printing and publishing accomplishments of immense complexity, acts of reproduction that approach an art form. Countless private pilots have papered their rec-room walls with sectionals, carefully pasted edge to edge to provide not only colorful wallpaper but a reminder of the enormous span of land that a set of wings can bridge. I don't know of any road maps that have been accorded the same honor. Unfortunately, you need Bill Gates' living room, or at least a wall 40 feet long and almost 20 high, to hang the 37 sectionals that cover just the 48 contiguous states. And there's one more for Hawaii and 16 for Alaska.

A typical sectional is almost five feet wide and more than a foot and a half high, printed on both sides. And like urban commuters who develop the ability to turn the pages of a newspaper in a packed subway car, pilots in cramped and often windy cockpits consider the proper folding and unfolding of a sectional a skill as important as leaning an engine's fuel mixture by ear. Even more demanding is the ability to pick up where you left off when your track suddenly migrates from one side of the sectional to the other. Indeed, each chart has instructions on how to handle that dilemma when you're plotting a course.

The compensation for the sectional's unwieldiness is the immensely satisfying proof of one's progress that comes when you move onto the Denver chart, say, and can fold up and put away the Wichita chart. Or, in the case of a slow airplane and a fast headwind, the equivalent is simply crossing a crease in the map and being able to rearrange the folds.

The base for each sectional—the primary map of the country's physical surface—is created from Department of the Interior Geological Survey 7.5 quadrangle maps, which are the delicately delineated maps that blanket the country in a scale so finely focused—each inch of paper is equivalent to a little over a third of a mile—that in rural areas, every house and barn is depicted. On a sectional, each quadrangle covers an area the size of a postage stamp, and it takes 2,000 of them to make up an entire sectional chart. (An inch on a sectional is just under eight miles.)

With the base established, each sectional is built from, typically, 53 layers of information, each layer a separate transparent sheet, all laid atop the map base. Each contains only the uniform graphics and color that are assigned to it. One layer has nothing but uncontrolled-airport symbols, little magenta circles with at most a runway or two shown. Another has control-tower airports, colored blue, with the runways depicted in scale. Another layer is nothing but man-made obstructions. Another: VOR (Very High Frequency Omnirange) compass roses. Another: yellow "urban tint" denoting built-up areas. Water. Highways. Drainage areas. Mountainous elevations. Radio-frequency boxes. Restricted areas. And so forth, amounting to, in the case of the particularly complex Los Angeles sectional, nearly 70 layers.

Continental U.S. sectionals are revised and reprinted every six months—twice the frequency of British and German air charts, which are generally considered to be in a class nearly as good as those of the U.S.—so the individual chart layers are constantly under revision. (Most Alaskan sectionals are renewed annually.) An updated master goes off to the printer every 28 days, since chart revisions are staggered to spread out the workload.

Changes can be wrought by everything from a private pilot calling AC&C (800-626-3677) with the news that the road west of Middletown shown as two lanes sure looked like four when he flew over it, to a mayor writing to announce that his town had just erected a new water tower and it would be swell if the chart honored it. Says Carl Nixon, chief of the Visual Chart Branch, "One of our best sources of new information is simply people flying around looking out the window. We get one or two tips a day, most of them phoned in."

Wander through AC&C's offices and you'll also see Rand McNally road atlases on many a desk. "We use the best available source of information," Nixon says, "whether it's a road atlas or a newspaper clipping." But this is only the first stage in a chart revision. AC&C never takes anything for granted, whether it's a phone call from a pilot, a letter from an electric company announcing completion of a power line, or even an official document from the Federal Aviation Administration. Everything is double-checked, sometimes by cartographers demanding photo verification.

The ultimate proof is "flight editing." NOAA has a small fleet of twin-engine airplanes—a Shrike Commander, Turbo Commander, and Citation business jet—that fly back and forth, over the ground covered by sectionals, like lawnmowers cutting row after row of grass. The in-house joke is that the pilots are simply scouting for nice places to retire to, but in fact they're checking virtually every item on the busier sectionals. They come back from their mind-numbing missions with notes that eventually are scribed onto the margins of the sectional under revision: "add new tower," "dragstrip still good landmark," "airport north of road," and, as the last of the drive-ins crumble, the frequent "delete outdoor theater."

"I get upset when pilots tell me that they can use an outdated chart for several years," Ronald Bolton says. "We can have 800 changes on a single sectional in one six-month cycle." Still, many pilots resist spending $7.25 per



Railroad Yard: Limiting Track to Scale

railroad yard

RAILROADS

RUSSIA

UNITED STATES

Convention or Mandate Line

INTERNATIONAL DATE LINE

(Monday)

(Sunday)

Date Line

BOUNDARIES

dark area

LANDMARK AREAS

numerous small lakes

Perennial
When too numerous to show individual lakes, show representative pattern and descriptive note

618

756

Non-Perennial
(dry, intermittent, etc.)
Illustration includes small perennial lake.

LAKES

WAC

AERIAL CABLEWAYS

CRANBERRY BOGS

TEMPLE

PROMINENT PICTORIALS

12632

MOUNTAIN PASS

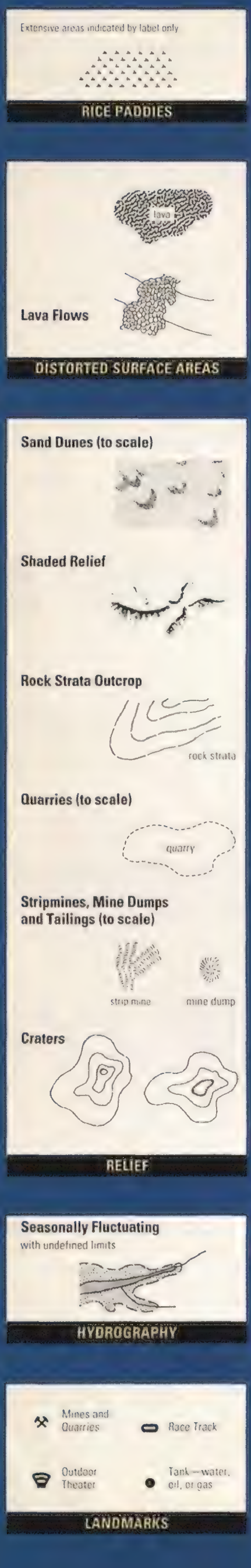




chart twice a year. Which in my case, as a pilot who ranges the occasional thousand miles from home base, means a not-unreasonable collection of 10 sectionals for compete coverage: $145 a year. Dare I upset Bolton? I break down and buy a new set of sectionals only when my prime chart—the New York sectional—wears out from constant use. (But if an FAA inspector ramp-checks my airplane and finds out-of-date charts, I could get the aeronautical equivalent of a ticket. And were I to have an accident, particularly as a result of getting lost, my negligence could be used against me in an FAA enforcement action.)

The Office of Aeronautical Charting and Cartography is on the cusp of change—some of it good, some of it the subject of much contention. For one thing, the Department of Commerce is trying to kick them out. "Commerce says we no longer fit in NOAA, which is primarily an environmental organization," says director Terry Laydon. "The aeronautical charting business started with charts intended to promote interstate aeronautical commerce, which is why I keep saying we belong in the Department of Commerce." Commerce, however, wants the AC&C shifted to the Department of Transportation, where it probably would be placed under the FAA. "We're concerned about that," says Laydon, "because it isn't clear that the FAA will support the non-aeronautical part of our activities, such as printing and distributing nautical and military charts." Laydon sees obvious efficiencies in the consolidation of such production.

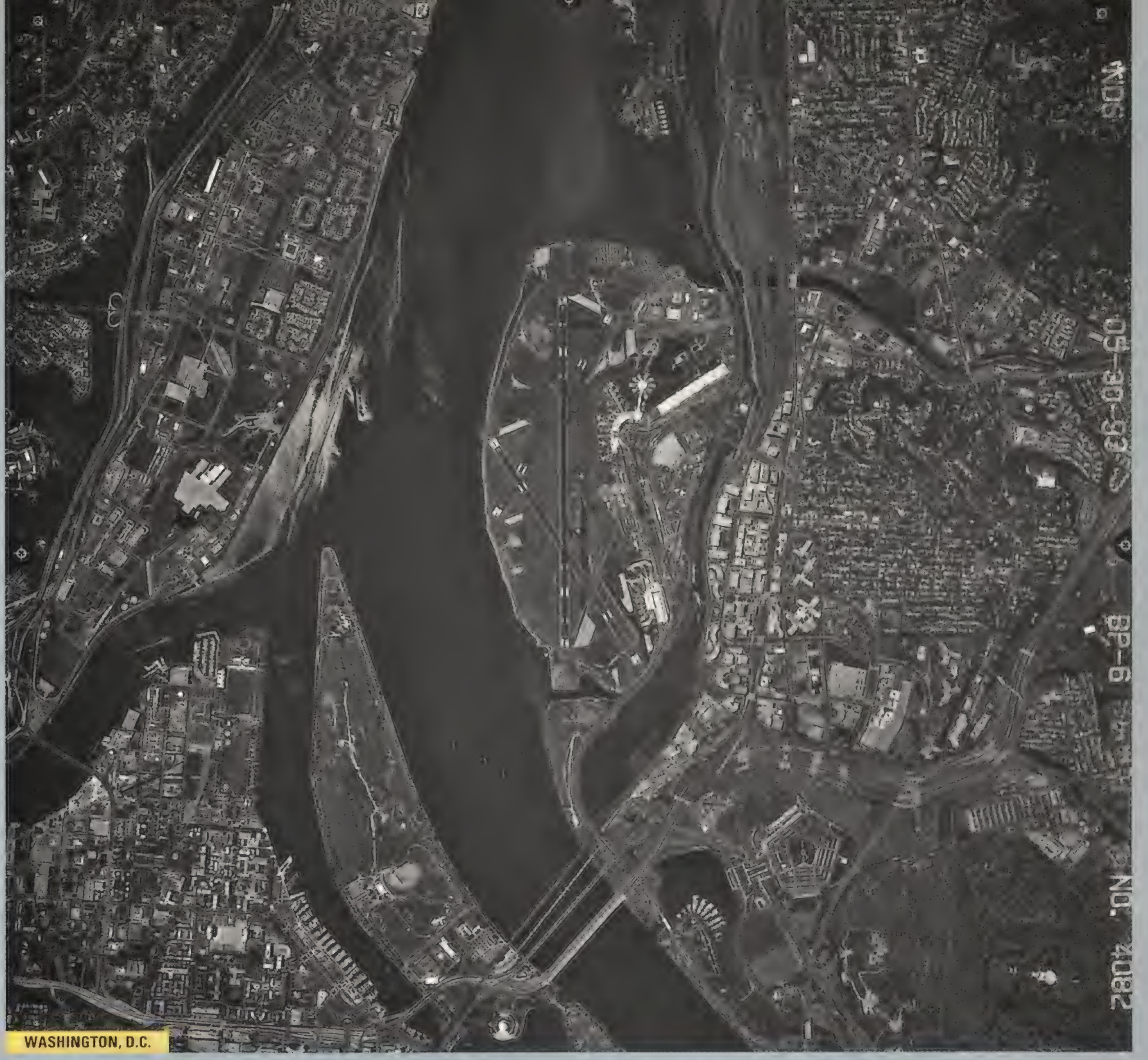
If they do go to the DOT, the Aeronautical Charting and Cartography Division will be renamed Transnav—short for Transportation Navigation Services. But this is the least of Laydon's concerns. "We don't have a lot of name recognition anyway," he says. "Our charts are known as 'NOS charts' [National Ocean Survey] or 'Nozz charts.' Nobody calls them AC&C charts."

The positive changes, however, are the AC&C's increasing reliance upon computerization and automation, the goal being the eventual disappearance of the cartographer's traditional tools and techniques. "It's a dying art," says printing specialist Nick Alsop as he demonstrates how corrections compiled from flight editing and other sources are hand-engraved onto huge plastic sheets. "We'll probably see all of our tools in the Smithsonian someday."

At one end of the spectrum are Alsop and senior cartographer Ray Harris, who uses nothing more than a Koh-i-Noor lead pencil, an eraser, and an X-Acto knife to endlessly, laboriously draw the properly shadowed lumpiness of thousands upon thousands of square miles of mountainous terrain all over the United States. Harris uses as his guide an underlay of U.S. Geological Survey topographic contour lines and an understanding of how the land will thus fall, fold, and furrow.

At the other extreme is young cartographer Rick Luzier, who toils at a computer workstation "drawing" a map with a keyboard and mouse—at the time I visited him he was working on a new, almost totally automated terminal area chart. (A TAC is an adjunct to a sectional that shows in large scale a single particularly busy city—Cincinnati, in this case—that has complex air carrier traffic and numerous altitude and airspace restrictions for light aircraft.)





WASHINGTON, D.C.

But Luzier's work shows why human input is still important. He calls up from a computer database the chart layer that depicts man-made obstructions. They are magically placed on the electronic map more precisely than any cartographer could, but some so exactly that their symbols obscure more important information, and so profusely that Cincinnati becomes a blur of black. The computer is undiscriminating and, as requested, obediently flags every building over 200 feet high, but only a few of the skyscrapers need representation. "Most of the things we do manually can be automated if we have the equipment," Alsop explains, "but there's no way to put that much symbology on a single sheet without human judgment coming into play to decide what to print and where to put it."

Says John Brennan, supervisor of the Eastern Chart Section, "You can't compromise quality just in the interest of making production more efficient. Automation is certainly the way to go, but we have to approach it cautiously. Once something [wrong] gets into the hands of the pilot, it's impossible to recall it. All the young cartographers here are rarin' to go on this new stuff, but we're being cautious."

Still, the AC&C has a tempting goal in sight as it turns more and more chart symbols, locations, landmarks, airways, elevations, and contours into electronic bits: "a seamless database that will go straight into cockpit moving-map displays without ever being on paper," says Bolton. "After all, we're accurate to within better than one pixel on a CRT screen."

For the old fogeys among us, however, nothing will ever replace the sectional—a "database" that is not only cheap, accurate, portable, durable, and convenient, but beautiful.

The Hush Heard 'Round the World

The European Union's recent rules on aircraft noise threaten U.S. aviation exports, ignore international standards, and amount to a declaration of trade war.

As we approach the end of a century that has been defined as much by our ties to Europe as by our cold war with Russia, we find ourselves in a new conflict. The U.S. aerospace industry has become a target of European protectionism and is bracing for a fight. The Europeans say it is a fight over aircraft noise; we believe it is a fight over a free market.

Current aircraft noise regulations around the world are based on limits negotiated within the International Civil Aviation Organization. The limits have been implemented in stages with increasingly restrictive requirements. Operations under so-called Stage 2 limits are now being phased out in favor of more stringent Stage 3 limits. All jet transports currently in production meet the newer Stage 3 limits, but the existing operational world fleet is a mix of Stage 2 and Stage 3 craft. Once the ban on Stage 2 operations takes effect on the agreed-upon date—April 1, 2002—Stage 2 aircraft must be retired or recertificated to meet the Stage 3 requirements.

Airlines and other jet transport operators have been recertificating their aircraft to comply with Stage 3 restrictions either by replacing the engines with newer, quieter ones, installing "hush kits," which act as a sort of muffler, or imposing noise-reducing operational limitations, such as restrictions on takeoff weight, flap settings, or engine thrust levels. But now many of these recertificated aircraft will be unable to land at European airports after April 1, 2002. The European Union at a recent session in Brussels voted into law a "non-addition rule" that bans entry of Stage 2 airplanes that have been recertificated to meet current Stage 3 noise requirements (as well as certain airplanes that already meet Stage 3), unless they have been registered or operated in an EU country prior to May 1, 1999. In response to objections to the ban by U.S. trade officials, the Europeans postponed its implementation for a year—giving operators until May 1, 2000, to operate a recertificated aircraft in a European country—under the condition that the ICAO would accelerate its efforts regarding new (Stage 4) jet engine standards.

> How do you begin to plan a new generation of aircraft when you suspect the EU might demand new standards a few years down the road?

On the face of it, this compromise sounds good. The Europeans are anxious for the development of jet engines that would reduce noise and emissions in the densely populated regions around their airports. So why don't we just get busy and invent quieter engines? And what's the problem with getting rid of those recertificated airplanes?

The aircraft affected by this rule have extensive life remaining in them—that is why operators went to the expense of bringing their aircraft up to the Stage 3 level in the first place. Banning these aircraft would create a financial hardship felt not only by the U.S. manufacturers and air carriers but also by less developed countries operating Stage 2 aircraft capable of being brought up to Stage 3 standards.

If the EU implements its ban, the loss of these markets for used aircraft would mean that airlines would be forced to depreciate these airplanes more quickly than they otherwise would, driving prices down to less than 50 percent of today's prevailing levels. The resale of older airplanes is the most frequently used method of acquiring the down payment for new aircraft, so losing 50 percent of the value of these airplanes will create a serious obstacle to fleet modernization.

The EU claims that it has adopted the non-addition rule for environmental reasons. We find this a dubious claim, since the EU has provided no engineering data to support its decision to ban recertificated aircraft, despite numerous requests from the U.S. industry and government. It should be noted that the noise measured near airports from these recertificated aircraft is lower than that from some aircraft manufactured to meet Stage 3 standards. Because of this fact, some acoustics experts have identified the complaints against hush-kit-equipped aircraft as a "psycho-acoustic" issue, meaning that when an aircraft is identified as a certain type that was noisy when first certified, people persist in perceiving that its noise is greater than its measured value.



The EU also claims that operational restrictions—on takeoff weight and engine thrust levels, for example—are

entary

by John W. Douglass

reversible and that aircraft that have been recertificated could subsequently be operated in violation of Stage 3 limits. But once the aircraft has been recertificated, these operational restrictions cannot be rescinded, and aviation authorities' record-keeping requirements would make infractions easy to detect.

So what's this all about?

The non-addition rule was carefully designed to discriminate against U.S. engine and hush kit manufacturers. The most obvious problem with the non-addition rule is that it is a design requirement, not a performance requirement. International rules regarding standards demonstrate a clear preference for performance-based rules, and there are sound reasons for this practice. Perhaps the most important as far as international trade is concerned is that it is easy to craft a design-based rule in such a way as to protect domestic industry from foreign competition.

Design requirements should be adopted only in rare and justifiable circumstances because applying them also turns out to be a great way to stifle innovation. Just imagine a government-imposed design requirement on computers. Similarly, the EU non-addition rule impedes creative thinking about ways to reduce aircraft noise.

If this EU regulation is allowed to stand, what will be next? Investment decisions in this industry rely on a stable regulatory environment in which aircraft can be produced and operated over a sufficient period of time to permit recovery of the investment. What is the next group of Stage 3 aircraft to be phased out by strictly regional considerations? How do you begin to plan for a new generation of aircraft when you suspect the EU might suddenly demand an even newer standard a few years down the road that makes your fresh-off-the-production-line aircraft obsolete? It defies reason to suggest that hundreds of aircraft valued at billions of dollars would have to be scrapped because of an arbitrary standard. And it is ironic that the European Union, in its effort to rid the skies of older aircraft, is going to destabilize the investment climate and impede funding of research in the very technologies needed for a new international consensus on noise reduction beyond Stage 3 levels. Furthermore, knowing that the EU may feel free to impose regional rules on a global industry such as aviation has soured negotiations for new standards.



DAVID POVILAITIS

In the absence of scientific analysis that demonstrates that the rule will result in noise abatement at European airports, we must conclude that this rule was designed to discriminate against U.S. business. The United States cannot allow environmental regulations to be used as a pretext for gaining competitive advantage.

As we end this century, the bureaucrats in Brussels should take note of the fact that we are Europe's biggest trading partner. Aerospace trade with England and France tops the list. In the case of France, we import aerospace products ($5.8 billion worth in 1998) valued in excess of a billion dollars more than we export. This will change if the EU continues to try to ban U.S. goods from the skies of Europe without a shred of rationale.

John W. Douglass is president, chief executive officer, and general manager of the Aerospace Industries Association. A former Assistant Secretary of the Navy and retired Air Force General, he served in the Office of the Secretary of the Air Force as Director of Plans and Policy and Director of Science and Technology and was later an advisor to Senator Sam Nunn.

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The One-Pound

by Tony Reichhardt *Illustrations by Paul DiMare*



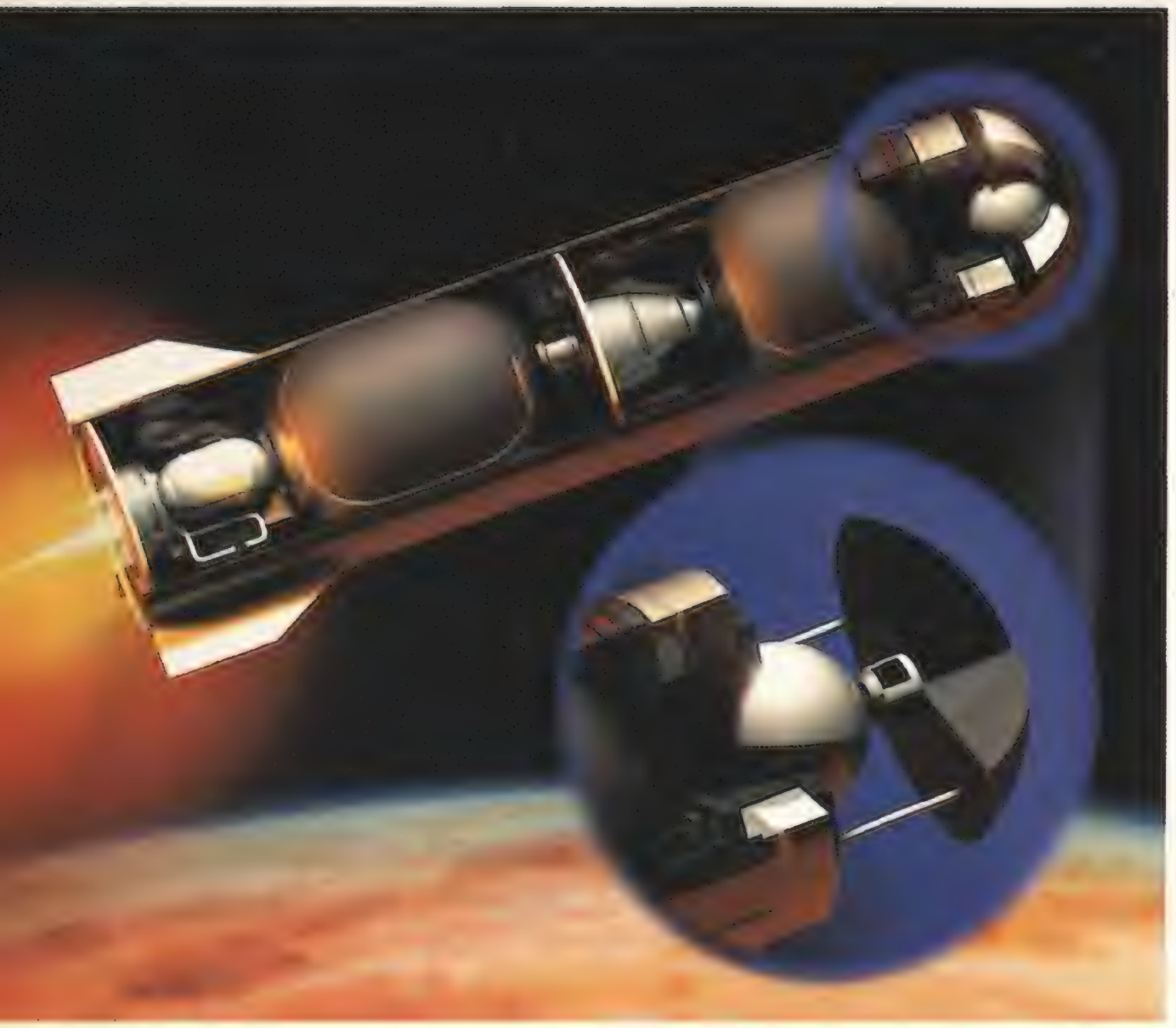
Problem

All the Mars Ascent Vehicle has to do is deliver 16 ounces of rocks in a container the size of a grapefruit to Martian orbit. If only it were as easy as it sounds.

When Brian Wilcox was growing up in the 1950s and '60s, his father was in the space business, and for a kid whose hobby was model rocketry, what could be better than that? Howard Wilcox worked on early launch systems for the Naval Ordnance Test Station in China Lake, California, then later for General Motors, where he designed robots that could have scouted landing sites for the Apollo astronauts (but never did). In those visionary days, when the rules of spaceflight were still being written, Brian and his father would have long talks about what kind of launch vehicles we would someday need on Mars, and whether the small model rockets he and his friends built could—in principle—reach Earth orbit.

The answer, sadly, was no. A former physics professor at Berkeley, Howard Wilcox knew it wasn't gravity that dictates the minimum size for a launcher. "My father explained to

May 2004: The Mars Ascent Vehicle, with samples onboard, will be the first rocket launched from another planet.



Although the MAV design is still evolving, it is likely to have two solid-fuel rocket stages. The spherical sample canister on top is released and will be picked up later in orbit.

me at a very young age that the only limitation was the atmosphere," Brian recalls. "If you didn't have an atmosphere, you *could* make them small." A terrestrial rocket has to push through a plug of air equivalent to a 30-foot column of water, and physics dictates that the smallest vehicle capable of moving all that atmospheric mass without paying a penalty in momentum is about 30 feet long.

On Mars, though, the thin atmosphere is equivalent to only about four inches of water. Many years later, working as an engineer at NASA's Jet Propulsion Laboratory, Brian Wilcox would participate in a key series of workshops to brainstorm ideas for a Mars sample-return mission, the most ambitious planetary project in history. One of the critical questions facing the workshop attendees, he remembers, was: What was the smallest rocket that could possibly leave the surface of Mars and make it into space? "And I knew that answer because I'd discussed it with my father many times. The answer is: about the size of a pencil."

Howard Wilcox didn't live to see his son's triumph on July 4, 1997, when, as a member of JPL's Mars Pathfinder team, Brian helped pull off the first spacecraft landing on Mars in more than two decades. Pathfinder was a watershed event for NASA. Its $265 million price tag proved that planetary missions didn't have to be expensive to be fun, and it gave planners confidence that the agency's goal to return samples of Martian soil to Earth by the middle of the next decade—which had just received a huge boost from the discovery of signs of possible fossil life in a Martian meteorite (see "Pieces of the Rock," Apr./May 1997)—was feasible for around $1 billion.

By the following spring, however, the confidence had all but evaporated. The sample-return mission—in fact the whole Mars exploration "architecture," which called for launching at least one spacecraft to the planet at every two-year opportunity—was running into severe financial and technical problems and was on the verge of meltdown.

The plan at the time of the Pathfinder landing called for three missions directed toward the goal of getting samples back from Mars. The first two would send large, well-equipped rovers to Mars in 2001 and 2003 to dig and drill rock samples from different sites, then "cache" them in sealed containers on the surface to await pickup. The third would dispatch a smaller "fetch rover" in 2005 to whichever of the two caches looked more promising scientifically. The little rover would trundle over to the chosen sample, bring it back to the lander, and transfer it to a rocket called the Mars Ascent Vehicle (MAV), which would send it back to Earth.

The scheme quickly ran into difficulties, though, that threatened to break the project's budget and schedule. The package launched to Mars in 2005—which included the lander, the fetch rover, the rocket, and miscellaneous other equipment—would have to fit inside a medium-size Delta launcher to make the mission affordable. And designing a lightweight Mars rocket that could live within that limit was turning into a very tough challenge.

The MAV was to be liquid-fueled, so it needed exotic propellant that wouldn't freeze during the Martian night. It required fancy plumbing, miniaturized components, and lightweight motors and fuel tanks. "It needed a whole bunch of stuff to try and get this thing down to a low mass," recalls Mark Adler, chief engineer for the sample return mission. "That was all extremely expensive." The price for the MAV ballooned to $120 million at a time when the entire project was budgeted for only $200 million a year. And, at 1,300 pounds, the thing was way overweight.

The MAV wasn't the only headache. The big sample-collecting rover was having its own development troubles, and getting it ready by 2001 looked like a long shot. Meanwhile, the human exploration office at NASA, realizing that sample return was the only train leaving for Mars, proposed adding an ex-

periment to the 2001 mission that would benefit future astronauts: a prototype propellant plant to extract oxygen and hydrogen from the Martian environment and make fuel for the rocket. The only catch was that the money had to come from JPL's fixed budget, which was now strained to the breaking point.

By the time Bill O'Neill, a manager who had come from the Galileo Jupiter mission, took over as head of the sample-return project early last year, "a lot of issues were out of control," he says. "As things unraveled, all the senior managers kind of pitched in and said, 'We've got to figure out a way to fix this.' " One of the things O'Neill did was hold a pair of workshops in spring 1998 at the Embassy Suites hotel in Arcadia, just down the freeway from JPL. His notion was to invite fresh ideas from inside and outside the team on how best to do a sample return.

Brian Wilcox wasn't working on the project—his expertise is rover design—and he was a bit self-conscious venturing outside his turf. But he asked to present a concept for a Mars rocket he'd had in the back of his mind for years, based on work his father had done at China Lake in the 1950s. "I was thrilled to be able to step forward and say 'Hey, I've got another way. And by the way, I've got a 19-minute videotape that shows how it can be done.' "

The video shows Howard Wilcox sporting a bow tie and crewcut, standing at a blackboard circa 1958, and looking for all the world like Mister Wizard as he chalks out the basics of a then-secret project called NOTSNIK. Wilcox and his team attempted—some think they succeeded in—launching a two-pound satellite to Earth orbit from under the wing of a Douglas Skyray fighter (see "The China Lake Launches," Feb./Mar. 1997). One of their innovations was to launch NOTSNIK's last rocket stage, the one attached to the satellite, with its nozzle pointing in a direction opposite from the other stages. When it reached space it coasted for half an orbit, spinning all the while to maintain its orientation, so that on the opposite side of Earth its "backward" nozzle was pointing in the right direction to boost the satellite to its final orbit. (Think of the spacecraft as a car on a ferris wheel, its nozzle pointed down on its downward arc. With its attitude held stable, its nozzle will continue to point down as the craft begins to climb and can accelerate it in the direction of its forward motion.) It was a clever way to avoid putting guidance electronics on the last stage and save precious weight in a system that measured performance in ounces.

What Wilcox proposed to the JPL workshop wasn't the theoretical pencil-size Mars rocket he and his father had once dreamed up, but it was close. The "Mini-MAV," as it was dubbed, weighed a mere 40 pounds and stood only three feet high. It could deliver seven ounces—200 grams—of Martian rock to orbit, a significant step toward the payload the team now hopes for. The first stage would be set spinning rapidly on a turntable just before launch, the second stage would spin up with small thrusters, and the third stage would pull its little NOTSNIK trick to point itself in the right direction. No active guidance at all. The Mini-MAV wouldn't need it, because another key assumption was changing at around the same time. Sample caching would now be done in Martian orbit instead of on the surface. A dumb—that is, imprecise—rocket could just lob the sample canister into space, where a smart orbiting spacecraft—supplied by France and sent to Mars by the powerful Ariane 5—would find it, rendezvous with it, capture the canister, and send it back to Earth.

Outside JPL, scientists and NASA managers who the year before had watched in horror as the sample-return mission nearly collapsed were now talking up Mini-MAV.

Scrapping the guidance system was "a very big deal," says Mark Adler, because it alone weighed tens of pounds compared to less than a pound for the sample itself. Any mass removed from the top of the rocket had tremendous leverage on the whole system. The ratio was eight to one: For every pound cut from the payload, you'd save eight in motor and fuel at the bottom.

At first, Mini-MAV appeared to be one of those rare engineering miracles that offers nothing but advantages. It was so lightweight that you could now get away with using lower-performance solid-rocket engines instead of liquid engines, with all their fussy plumbing and sensitivity to the cold. And solid rockets, with their relatively simple technology, could be ready by 2003, while the large liquid MAV couldn't. Finally, NASA could return samples from both cached sites, one in 2003 and one in 2005.

That summer, Wilcox gave presentations on his idea to other groups hashing out the Mars architecture, and no one shot it down. In fact, with each level of review the enthusiasm only mounted. One veteran space consultant whom O'Neill had hired to help rethink the sample-return mission was so jazzed about Mini-MAV that he canceled a long-planned European vacation to keep working on it. Adler was excited too, but cautious. "My initial thought was *Gee, that's a good idea. I wonder if it works.*" A couple of small teams at JPL were asked to give it a closer look.

Doug Caldwell, a young engineer who had left the computer industry six years earlier to join JPL, took over as the new head of the MAV office in September 1998. Before that, working on the Deep Space 1 technology demo mission, he had heard "a crazy idea of a spinning rocket that will weigh only 30 or 40 kilograms," and was well aware of the buzz surrounding it. Outside JPL, scientists and NASA managers who the year before had watched in horror as the sample-return mission nearly collapsed were now talking up Mini-MAV "like it's going to completely *save the world,*" says Caldwell. And he thought to himself, *Yeah, but you don't actually have to build it!*

He thought the idea was cool too, and still does. But he knew that "whenever someone throws out something brand new, it almost always looks better" than what you've got in front of you. And the study teams were already

beginning to find cracks in the Mini-MAV miracle. "A lot of the simplifications turned out to be oversimplifications," says Caldwell.

For starters, the rocket's conjectured 45-pound weight hadn't included the turntable on which it rested, the "igloo" covering needed to keep it warm, or other sundry equipment not on the rocket itself. Add another 35 pounds right off the bat.

The NOTSNIK had done without a guidance system partly by using fins to stabilize itself in the atmosphere, but the Martian air was too thin to help here. Plus, the NOTSNIK engineers hadn't been picky about where their satellite wound up, as long as it made it into orbit. The Mini-MAV couldn't be quite that loose—it had to come within striking distance of the Mars orbiter.

"God created guidance systems for a purpose," says Caldwell. So the engineers admitted defeat and added active control—thrusters, inertial position sensors, computers, and power—to the first stage, which pushed the weight up from 80 pounds to almost 300.

Another issue the Mini-MAV design hadn't addressed was how the sample canister would keep the Martian dirt pristine. This was important not only to scientists, who wanted uncontaminated samples, but to NASA's "planetary protection" watchdogs, who had to guarantee to the public that no dangerous Martian bug—a remote possibility, but not entirely out of the question—would be returned to Earth. The sample-return project hadn't yet come to grips with the planetary protection dilemma when Brian Wilcox proposed his Mini-MAV. By the time it did, the sphere that could hold the Martian dirt and keep it sterile weighed ten times more than the sample itself.

This creeping weight gain was fairly typical for the early design phase of a space engineering project, says Caldwell. "Push the system here and it bulges out there with some kind of problem—too much heat, or cost, or weight." It was mainly that damn eight-to-one mass penalty. When anyone suggested adding another pound or two to the sample canister, he says, "I wanted them to know how painful it is."

By the spring of this year, the Mini-MAV had ballooned up to a 375-pound, plain old MAV, which stood about as tall as a person. It was still a lot better than the old liquid-fueled MAV, which had trimmed down to 600 pounds but appeared to be stuck there. Even so, with all the commotion that had been made over the Mini-MAV, Caldwell couldn't help feeling like the guy who's been given a perfect handoff, only to fumble it inches from the goal line.

Asked what's the hardest part of bringing back a sample from Mars, Bill O'Neill thinks for a moment, looks down at his desk, and takes in a deep breath. Then he lets it out with a laugh. "It's *all* hard!"

He considers each task of the three missions in order (see diagram, opposite page). Getting to Mars is straightforward enough. But two of the flight plans call for "direct insertion" by aerocapture. In other words, the spacecraft will come screaming into the Martian atmosphere, where drag, not retrorockets, will slow it down. It's never been tried.

The greatest worry is time. The rover is expected to last only 90 days on the surface of Mars before it runs out of electrical power.

Once safely on the ground, the 2003 and 2005 landers will deploy rovers about the size of a child's wagon, which will roam the Martian surface, collecting rocks and drilling cores from some 20 sites over the course of three months. The most interesting samples will go into a cache box, which will be transferred to the MAV when the rover returns to the lander. A mechanical arm then hoists the MAV to vertical launch position, and off it goes.

Still pondering the relative risks, O'Neill says the landing on Mars isn't too bad, since it's been done before. The rover can be tested on Earth. The transfer from rover to MAV is tricky, but also can be practiced beforehand. "I suppose if I had to pick something, I would say the ascent vehicle, because it's the least demonstratable," says O'Neill. "There's no environment you can find on Earth that can completely mimic what we're going to do at Mars."

The sample-return strategists will therefore rely mostly on computer simulation, just like the Mars Pathfinder team did, testing only those few key elements that are particularly worrisome and are possible to try out on Earth. For example, Doug Caldwell wants to run what he calls a "burp test" in a 100-foot-high chamber filled with simulated Martian atmosphere. A MAV would be loaded with just enough solid propellant to burn for a second or so—long enough for the rocket to clear the launch deck so the engineers can see if its exhaust plume has some funny interaction with the lander.

The sample return mission becomes much more difficult the more Martian dirt the project is asked to bring back, and last spring this was a topic of vigorous discussion between JPL and NASA Headquarters. By then Caldwell and company knew how to build a MAV that could lift about 12 ounces—350 grams. But NASA was "adamant," says O'Neill, that it wanted the full pound—a little more than a pound, in fact, 500 grams, about 17 ounces—and was pushing for a "stretch goal" of 1,000 grams.

The can-do team at JPL didn't argue that it was impossible. "We wouldn't want to immediately take the easy way," says O'Neill. But bringing back more sample doesn't automatically increase the scientific productivity of the mission. The project had long ago rejected what was known as the "grab sample" scenario—dash to Mars, dig up a bunch of dirt in a hurry from right around the lander, then rush it back to Earth. To maximize their chance of finding evidence of water or some other geologic prize, the scientists much prefer collecting smaller samples from many diverse sites, with cameras and other instruments on the rover carefully documenting each setting. All they need is a few milligrams back in the lab—if it's the right rock.

This requires that the cache box be divided like a honeycomb into compartments, each containing a sealed sample from a different site. The greatest worry is time. It takes time for sci-



entists on Earth to study the surface photos and determine which sites they want to explore, time for the rover to move on to the next location, time to photograph the site up close, time to inspect each rock in the vicinity, time to drill the inch-long cores, and time to seal them in the compartments. The rover is expected to last only 90 days on the surface before dust and general wear and tear reduce the effectiveness of its solar arrays and it runs out of electrical power.

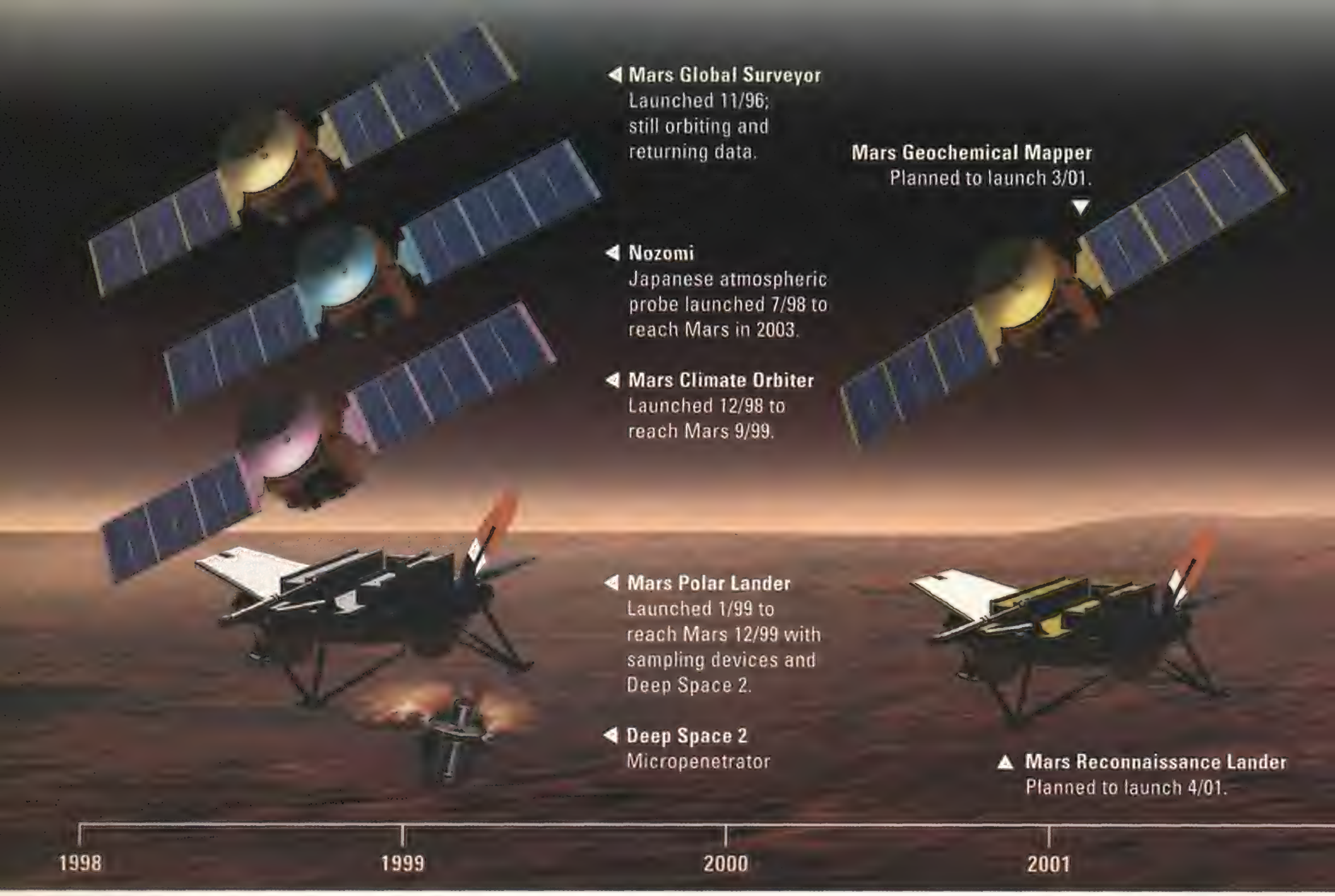
"Our job would be a lot easier if we could power the landers with nuclear batteries the way Viking did," says O'Neill. "But it's politically no longer acceptable." So three months is all the rover will have to do its job, and some question whether that's long enough to collect 500 grams of material from 20 different sites. "We'll be hard pressed to get enough stuff to fill up the cache boxes," says O'Neill. Steven Squyres of Cornell University, one of the lead scientists for the sample return, shares his concern. "This mission is going to be like that old supermarket sweepstakes, where you've got 90 seconds to go through the aisles, grabbing everything you can," he says.

Returning more than 500 grams could mean that some of the stuff gets tossed quickly into an undifferentiated bin at the end of the rover's lifetime, which isn't as appealing to scientists. And this loose dirt would have to be balanced in some way so it didn't slosh around when the MAV lifted off.

That, plus the general penalty for adding mass to the sample return canister, made even a few extra grams of material worth arguing about. JPL now feels comfortable with the 500-gram requirement, but "We don't know how we could get from 500 to 1,000 grams," says O'Neill. The difference is about the weight of a slim hardbound book.

How to get a sample from Mars to Earth, in five not-so-easy steps: (1) Rovers launched from Earth in 2003 and 2005 each spend three months on the surface collecting soil. (2) The samples are then transferred to a spherical canister on top of the MAV, which is (3) raised to a vertical position and launched. (4) The grapefruit-size canister is released. (5) The orbiter locates and "swallows" both the 2003 and 2005 canisters and places them in a capsule to be sent to Earth. Arrival in Utah is planned for 2008.

On an unseasonably cold April day in Pasadena, with patches of snow still clinging to the peaks of the San Gabriel mountains that abut the JPL campus, around 50 engineers and technical managers from the space industry gathered, at Caldwell's invitation,



for an all-day briefing on MAV. In coats and ties, unusual attire for JPL, they sat mostly silent while O'Neill tried to get them as pumped up as government contractors are allowed to get.

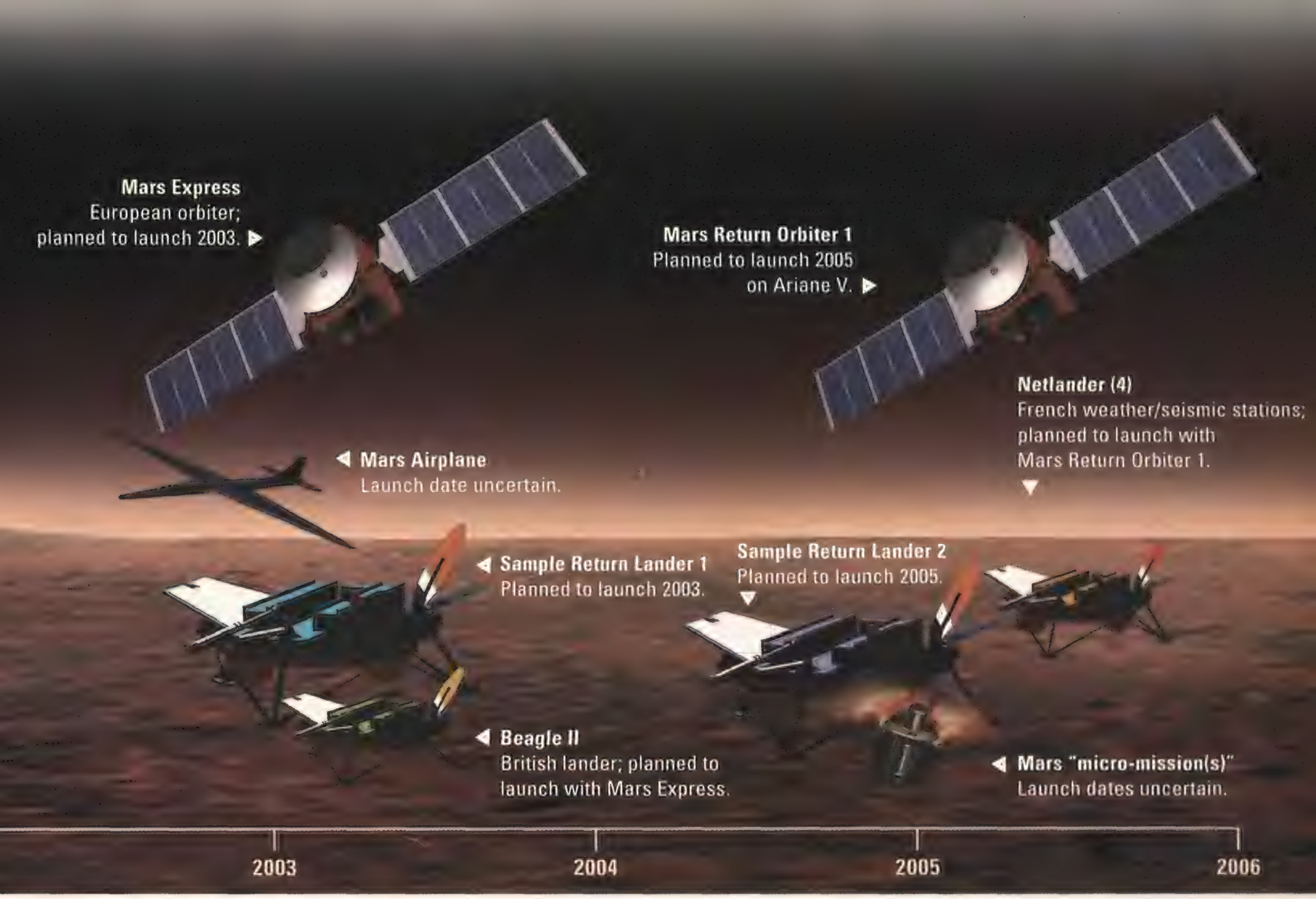
"The first-ever launch from another planet—what a great thing to be able to participate in!" he enthused, kicking off the meeting with a quick Vu-Graph walk-through of the sample-return mission. Bringing back a piece of another world, he continued, was "one of the few remaining firsts in planetary exploration," a historic endeavor on a par with Sputnik or Apollo.

Caldwell, introducing himself as the "MAVman," explained the reason for the meeting: JPL wanted an outside opinion. Most of the $60 million to be spent on the rocket system would go to contractors once actual fabrication began. Right now, though, he was looking for a reality check before going any further. "Do we have the right architecture?" he asked.

The MAV design was holding at about 375 pounds, and mission planners were hoping to drop to 350. It still called for three solid rocket stages: a guided first stage, spinning second and third stages, plus that additional NOTSNIK back-end-first approach on the third. One area in which the team needed advice was on the fuel composition for the solid rockets, because spinning had certain drawbacks. A key reason for rejecting the spinning first stage early on was that it required something like 500 rpm for accurate pointing. But even with a slower spin rate for the upper stages, people were concerned about the buildup of aluminum slag. Solid rockets on Earth typically are made with 16 to 18 percent aluminum. The more aluminum, the more *oomph.* But when the fuel burns, it produces aluminum oxide slag, which in a spinning rocket would throw off the balance like an uneven load of laundry in a washing machine. The answer appeared to be to cut the aluminum content way back, to one or two percent, but the exact formulation would have to be determined. Caldwell wanted a new team to look just at propulsion.

Some of the people attending the April briefing worked for companies—notably Lockheed Martin, part of which used to be Martin Marietta—that had been fiddling with Mars rocket concepts for at least 20 years. Most of these were old-style behemoth designs unsuited to the more economy-minded NASA of the 1990s. Later, back in his office, Mark Adler pointed to one of the old artist's conceptions showing a big, heavy rocket with an elaborate gantry—on *Mars*. "This is part of a ten-billion-dollar sample-return mission that never flew," he chuckled. "I can't imagine why not."

Still, there were some good, experienced Mars mission designers in industry, and by mid-summer Caldwell had hired two study teams—one to look at propulsion and the other to evaluate the overall system architecture with a fresh perspective. Almost immediately the teams found ways to improve the MAV. Based on some of the contractor presentations, it started to look like two stages would be better than three. It was a lot simpler and it saved weight: one less interface between stages, no third propulsion system. Even without guidance on the second and third stages, the trade stud-



ies showed that the old version was still heavier and more expensive. It was actually pretty obvious, says Caldwell. But "you get mentally tied to a concept," and the JPL engineers had been trying their damnedest to make the MAV work with the spinning upper stages stabilized NOTSNIK-style. Now none of that would be necessary.

And so, hardly a year after it was first proposed, the last vestige of Mini-MAV simply disappeared.

What had Brian Wilcox's novel idea, so celebrated just a few months earlier, really contributed then? "What it really did was force the thinking in a different direction," says Caldwell—away from big, heavy liquid engines and a design gridlock that had all but paralyzed the project.

Frank Jordan, a senior JPL manager in charge of Mars mission planning and an old hand at planetary spacecraft design, thinks that Mini-MAV deserved its accolades. "Most of the rah-rah was justified, in my view," he says. "I mean, it's not a 20-kilogram little-bitty rocket anymore, but it's 170 kilograms, and that's better than 300 kilograms." Jordan has seen a lot of engineering concepts come and go. He worked on the first mission to orbit Mars, Mariner 9, which entered Martian orbit in 1971. "So much of engineering, I think, works this way," he says. "You have some really innovative something, and by the time you bring it to fruition it's compromised—but still better."

The Mars rocket is still evolving, and it's still hard work. Caldwell and his team hope to have the design pretty well nailed down by December. Meanwhile, Wilcox has moved on to other projects and, like most people at JPL, has several things on his plate. He doesn't especially mind that in the end, his Mini-MAV didn't prove practical for the Mars sample return. Logic prevailed just as it did in the 1950s, when his father was trying to orbit another small object around another planet. Back then, scrapping the guidance system made sense because it weighed a lot more than NOTSNIK's payload. Once the payload grows beyond a certain size, the advantage is always with active guidance, and the MAV sample canister turned out to be much heavier than Mini-MAV's 200-gram payload.

The launch of Mars Global Surveyor in 1996 began an unprecedented era of Mars exploration by a number of spacefaring countries.

Wilcox spends most of his time these days building a tiny "nano-rover" to roam the surface of an asteroid, which will be included on a Japanese mission called MUSES-C, scheduled for launch in 2002. He has ideas for true Mini-MAVs, rockets so small they could be ferried around the Martian surface on the backs of rovers—that is, if the payload delivered to orbit were small enough. Then there's the Venus Sample Return concept he and others at JPL have been cooking up. They'd use a balloon to float a golf-ball-size sample up through the thick Venusian atmosphere to an altitude of 40 miles, where they would then fire a rocket from the balloon (just like NOTSNIK did from an airplane) to continue the journey to orbit. Now *that*, Brian's father might have agreed, is pretty clever—if it works.

Working for the Wright

PHOTOGRAPHS COURTESY QUENTIN WALD

What my father learned at the Wright Company about hydroaeroplanes, close calls, and practical jokes.

by Quentin Wald



Brothers

In 1905, Charles Wald, a young U.S. Customs Service employee stationed in the Philippines, came upon an article describing successful flights by Orville and Wilbur Wright; the piece was illustrated with photographs of the brothers flying a glider at Kitty Hawk, North Carolina. Wald was immediately excited by the possibilities. In 1906 he returned to the United States and, on his way east, stopped in Dayton to visit the Wrights.

To his surprise, they invited him to their home, where he met their father, Bishop Milton Wright, and sister, Katharine. Apparently, however, they said little to encourage his interest in flying except to advise him to learn some engineering. Wald went on to New York, where he continued his employment with the Customs Service, but he also enrolled in night courses in engineering at Pratt Institute.

Over the next several years, he attended every flying event he heard about. In September 1909, he, along with thousands of New Yorkers, watched as Wilbur Wright made a spectacular flight up the Hudson to Grant's tomb and back. At another flight around that time, Wald was struck by a remarkable demonstration of Wilbur's resourcefulness: The pilot took off, flew for a short time, then landed; evidently dissatisfied with the load on the engine, he proceeded to saw a bit off the tip of each propeller blade, rasp the ends fair and smooth, and then take off again.

During those years in New York, Wald wrote several times to the Wrights, asking for a job. His requests were finally rewarded in 1911, when they gave him a job in the shop at the Wright Company factory in Dayton. But after only a few months, the need for his services diminished and he was let go. He returned to New York, though he no longer had a job with the Customs Service. He wrote to Orville Wright, reminding him of his offer of reemployment "when business warranted." On March 18, 1912, Orville replied, offering another job in the shop. The pay

Harry Atwood was tricked by the other Wright student pilots into "practicing his sense of balance" on this cart. (Orville Wright is in the group at right, wearing a bowler.)



would be 25 to 35 cents per hour, and this time, in addition to employment, the Wrights offered Wald the opportunity to learn to fly. Wald began flight training with the Wright Company at Huffman Prairie, a pasture eight miles east of Dayton.

Charles Wald was my father, and from him I have inherited many photographs of those early flying experiences, his logbook, and a few old news clippings. I also have memories of some of his accounts of flying in the Wright machines and the men who flew with him. In addition, he told me about a "hydroaeroplane" school that Orville Wright tried to start on Long Island.

Wald's flight training began with instruction by Art Welsh in a Wright machine that had been of the original type and was later converted to the Model B configuration. (All Wright machines before 1910 had biplane elevators—twin control surfaces positioned ahead of the wings to pitch the airplane up and down, an arrangement we now call a canard configuration. The Model B, introduced in 1911, had a single horizontal control surface attached to the tail frame, behind the double rudder.)

Welsh instructed Wald every day that weather permitted, except Sundays. In the Model B, the pilot and passenger (or student) sat side by side on the lower wing over the front wing spar. The wing loading of the Wright machines—the weight of the aircraft divided by the wing area—was an extremely light two and a half pounds per square foot, so the craft were very sensitive to gusts and turbulent air. Flight instruction began very early in the morning, when the air was still, and usually ended when the sun's rays began to warm the field and stir up thermal air currents. Flying was usually resumed after 5 p.m., when the air was again calm.

Wald's logbook entry for Friday, April 12, reads: *"First lesson 9 minutes. A.L. Welsh instructor remarks 'good work' after first flight[;] handle both levers, second flight 3 minutes duration, 2 errors in warp on turning, Welsh advises practice on balancer."*

The "balancer" was the world's first flight simulator—an old airplane balanced on a trestle. The lever for lateral control was connected by wires to clutches at one wingtip that could engage continuously moving, motor-driven belts external to the aircraft. The primitive simulator provided the student pilots a means of practicing the use of the very unnatural system for lateral control that the Wrights used. Moving the control lever forward brought the left wing down; moving it backward depressed the right wing. Unfortunately, no photograph of the contraption has been found.

Logbook, Tuesday, April 16: *Get up 5 A.M. brisk wind no flying. Bergdoll finishes with 10 minute flight in P.M. Capt. Baldwin and Orville Wright on field, Baldwin refuses flight with Orville on account of wind. Orville has fun at Capt's expense.*

Tuesday, April 23: *6 landings rather hard, slight improvement at finish. Last landing cut off power at 100 ft. altitude. Welsh thinks no more time necessary. Start for New York 8:50 P.M.*

After 14 flights (none solo) totalling two hours and 46 minutes, Charles Wald's flight instruction was consid-

Wald and the other students began flight instruction very early in the morning, when the air was still, and ended when the sun's rays began to stir up thermal air currents. Flying usually resumed after 5 p.m., when the air was again calm.

ered complete. So was his job. Although the Wrights had agreed to teach Wald to fly, they evidently had no need of his services when his training was done. For the second time he returned to New York, jobless.

On May 30, Wilbur Wright died of typhoid fever. Twelve days later, Wald's former instructor, Art Welsh, and Lieutenant Leighton Hazelhurst of the Army Signal Corps were killed in the crash of a Wright machine at a field in College Park, Maryland.

On June 12, 1912, Wald sent Orville Wright a letter that read in part:

My dear Mr. Wright:
Lately you have had more sorrow and anxiety than is usually allotted to the average man in a lifetime and I have felt the loss and pangs of grief as much as anybody possibly could outside of your immediate family, consequently I feel a timidity in broaching a subject on material things and business.

Realizing that my late friend Mr. Welsh's place must be filled and the work must go on, I take the liberty of writing you on this rather delicate subject reminding you that in the past you have promised me consideration in case of a vacancy....
Very respectfully yours,
Chas Wald

Orville Wright sent a brief response, dated June 19, 1912, which concluded: "In our talk over a man to take Mr. Welsh's place, you were given special consideration, so that I think it would be well for you to see Mr. Barnes about the matter."

The matter was settled, and on June 27, Charles Wald was back at Huffman Prairie. That day, he finally made his first solo flight. The machine in which he made it was an old one that had been modified from the front elevator configuration but was now rebuilt to the true "B" configuration and designated B-14. It had not been flight tested since the overhaul, and the new pilot discovered that it tended to roll to the right and the control wires were too tight.

The Wright four-cylinder engine had no throttle control, only a foot-operated spark-retarding device that provided a measure of power reduction. On attempting to reduce power, Wald found the control was jammed. Since the engine was on the wing at the pilot's right hand, he was able to try to free the jammed spark retard control. Suddenly he realized that he was rapidly approaching two large trees with a rather narrow space between them. With what seemed to him a violent maneuver, he passed between the trees. Not surprisingly, the log concludes "*...rough landing. Time 5 P.M.*" So ended the 10-minute solo flight.

On the following day he flew for 15 minutes with Orville Wright next to him, checking his competence. "*Mr. Wright makes adjustments on machine,*" reads the log entry.

From that time until August 6, he flew every day except Sundays and two days spent in the shop when high winds prevented flying.

Between morning and evening flying, Wald and the other students spent many hours in the shop working on the engines and making repairs. In the training at Huffman Prairie, the Wright pilots acquired extensive experience in repairs of every description. Propellers, wing ribs, and skids all sustained frequent damage. The rollers on the propeller drive chains often broke, as did various engine parts. Wald's logbook reveals that the machines would be repaired and flown only days after being rather seriously damaged.

Sometimes the students would amuse themselves with a little horseplay. One of them, Harry Atwood (see *Skylark*, Reviews & Previews, p. 88), apparently



Opposite: Charles Wald in a Model B in April 1912. Right: Wald and A.L. Welsh over Huffman Prairie.

Wright employees might spend a few hours repairing parts, a few more flying the brothers' latest machine, and then take a break for a little mischief.

because of a somewhat arrogant attitude, became the victim of hazing. In one instance, the students persuaded him to whitewash a line across the field, ostensibly to use as a guide for learning to fly straight. Another time, someone told Atwood to try developing his sense of balance by standing on the axle of a two-wheel cart, balancing himself as long as possible while one of the others kept time with a stopwatch. "Mr. Wright finally put a stop to this," Wald recalled later.

On those days when the weather prevented flying and nothing needed immediate repair, the students entertained themselves with poker games in "the shed," the hangar the Wrights had constructed at Huffman Prairie.

But whenever possible, the students flew. One can imagine those hot summer days, a clattering machine with pilot in cap and shirt sleeves skimming in wide turns low over the Ohio prairie around a clump of ancient trees.

It seems to be a forgotten chapter in aviation history: In 1912, the Wright Company tried to establish a school of water flying, occasionally referred to as the Wright Air Ferry, at the Glenwood Country Club at Glen Head, New York. I have never found any references to it in history books.

Most aviation historians tell us that the Wright company first experimented with water-based aircraft in 1913. For example, in *The Papers of Wilbur and Orville Wright*, editor Marvin McFarland writes: "The CH was the first Wright hydroplane.... In experiments made on a secluded stretch of the Miami River near Dayton in the spring of 1913, two 'multi-step' pontoons...were attached to the skid runners." In addition, the Wright archives at Wright State University in Dayton, Ohio, has an excellent photograph of a machine in the Wright factory that I have identified as a Model B with floats; the picture is dated 1913, but that date is probably wrong. The picture most likely shows the machine being prepared for transport to Glen Head in 1912.

The operation was set up on the shore of Long Island Sound in a region where the very wealthy had estates and did a great deal of yachting. The company hoped to sell water flying lessons to the rich residents. Charles Wald was put in charge of the school. As far as I know, he was the only Wright employee detailed to the base, though at some point Orville joined him.

The machine used was a Wright Model B, designated number B-9, powered with the four-cylinder water-cooled Wright engine used in most Wright machines from 1908 through 1912. B-9 was an old machine, having been converted from the older Wright configuration to the "B" configuration. It was fitted with a pair of wooden floats with three steps—breaks in the bottom intended to reduce the area in contact with the water and thereby the hydrodynamic friction. It also had a water rudder, which was attached to the air rudder and hung below it.



When he arrived at Glen Head, Charles Wald had never flown the hydroaeroplane. (Almost certainly Orville Wright would have test flown the machine before it was sent from the factory in Dayton to Long Island.) Wald made the first flight at Glen Head early on the morning of September 9. From the log: "*Machine leaves water in 100 to 200 yards, little spray, smooth sea....*" The flight lasted 35 minutes. In another flight that day, with the water very smooth, Wald was unable to judge his height above the surface and struck the water in a turn. Two elevator spars and four wing ribs were broken. Judging height above glassy-smooth water later became a well-known difficulty to marine pilots, but Wald, with no instruction in water flying, was discovering that art for himself. He was flying again eight days later.

On September 21, having acquired more experience with the machine, Wald flew to New Rochelle Harbor, nine miles across Long Island Sound, carrying a token cargo of newspapers. This flight stirred public interest, and the craft in the harbor greeted the hydroaeroplane enthusiastically with horns and whistles. Wald made the return flight the following day, a Sunday, and earned a reprimand from Orville Wright for flying on the sabbath.

The next day, one J.C. Jackson became the first passenger of the "hydro," as Wald referred to it in his log. Wald recorded: "*...machine leaves water with an additional run of about 50%* [*i.e., carrying a passenger*]. *Plenty of reserve power in air.*" With the extra weight of a passenger, as well as the weight of the floats, it is remarkable that a machine with a 35-horsepower engine was able to get off the water at all. That it could do so is a tribute to, among other things, the very efficient Wright propellers.

Following this flight some changes were made in the position of the floats. The photographs show that the volume of the floats was probably not sufficient to provide more than marginal buoyancy, and in choppy water, there must have been considerable risk of



the craft plowing in and even pitching end over end. It was probably at this time that Orville Wright attached a small canvas lifting surface near the bow of each float to provide hydrodynamic lift upon contact with the water and prevent plowing in. However, when Wald took off, he very nearly came to disaster: In the air, the surfaces created aerodynamic lift, causing severe nose-up trim. They were removed before the next flight.

On October 4, Wald carried a second passenger, C.G. Goddard, in a 12-minute flight. The next day, Wald flew to Larchmont, then to New Rochelle, and returned to Glen Head.

On October 10, while preparing the machine for flight, Wald became aware that a man had fallen overboard from a rowboat some distance offshore. Wald launched the machine and, barely skimming the wave crests, quickly reaching the exhausted man, pulling him aboard and putting him in the passenger's seat. The newspapers quickly picked up the event and widely reported it. A photo of a reenactment of the rescue was printed and several rather lurid Sunday supplement articles, trumpeting the advent of aerial rescue, followed.

The evening of the same day, Wald carried Marion G. Peck, a newspaper reporter, as a passenger. As fog gathered during the evening chill, the magneto became saturated, causing the engine to miss. With the extra load and a malfunctioning engine, the hydroplane was unable to rise above the water enough to turn into the wind, so Wald attempted a downwind landing. The floats plowed in and the machine flipped over on its back. Wald was briefly trapped in the water amid the wire bracing. When he surfaced, the indomitable Miss Peck was already seated on a float, saying, "I was afraid you were never coming up!" The wet, chilled pair sat on the floats for several hours in the gathering darkness before being picked up by a passing fishing boat.

This eventful day concluded the activities of the Wright Air Ferry for the season and for all time. The hydro had made 13 flights and spent a bit over five hours in the air, although the log on which that is based could be incomplete. Wald claimed to have reached an altitude of 4,500 feet in this machine, which was, in 1912, an unofficial record for a water-based aircraft.

There is no record of any flight instruction being given at Glen Head. The failure to attract students may have been the reason Orville Wright abandoned the operation there.

When the Wright Company closed down the school, it also let Wald go. On leaving the company, he, with several friends, formed the short-lived Manhattan Aeroplane Company, which, in 1913, built two or three airplanes, one of which was a flying boat.

During World War I, he supervised part of the operations of the Curtiss factory in Buffalo, New York, where most U.S. aircraft were built in this period. Later he worked in naval aviation, retiring from the Navy's Bureau of Aeronautics in 1947. He died in 1967.

My father was proud of his experiences working for the Wright Company, but he did not elaborate on his accounts. Unfortunately, only when it was too late did I have the curiosity and the aeronautical knowledge to want more details about those early flying machines and the men who flew them. By going through his things, as well as comparing records, I have been able to learn more.

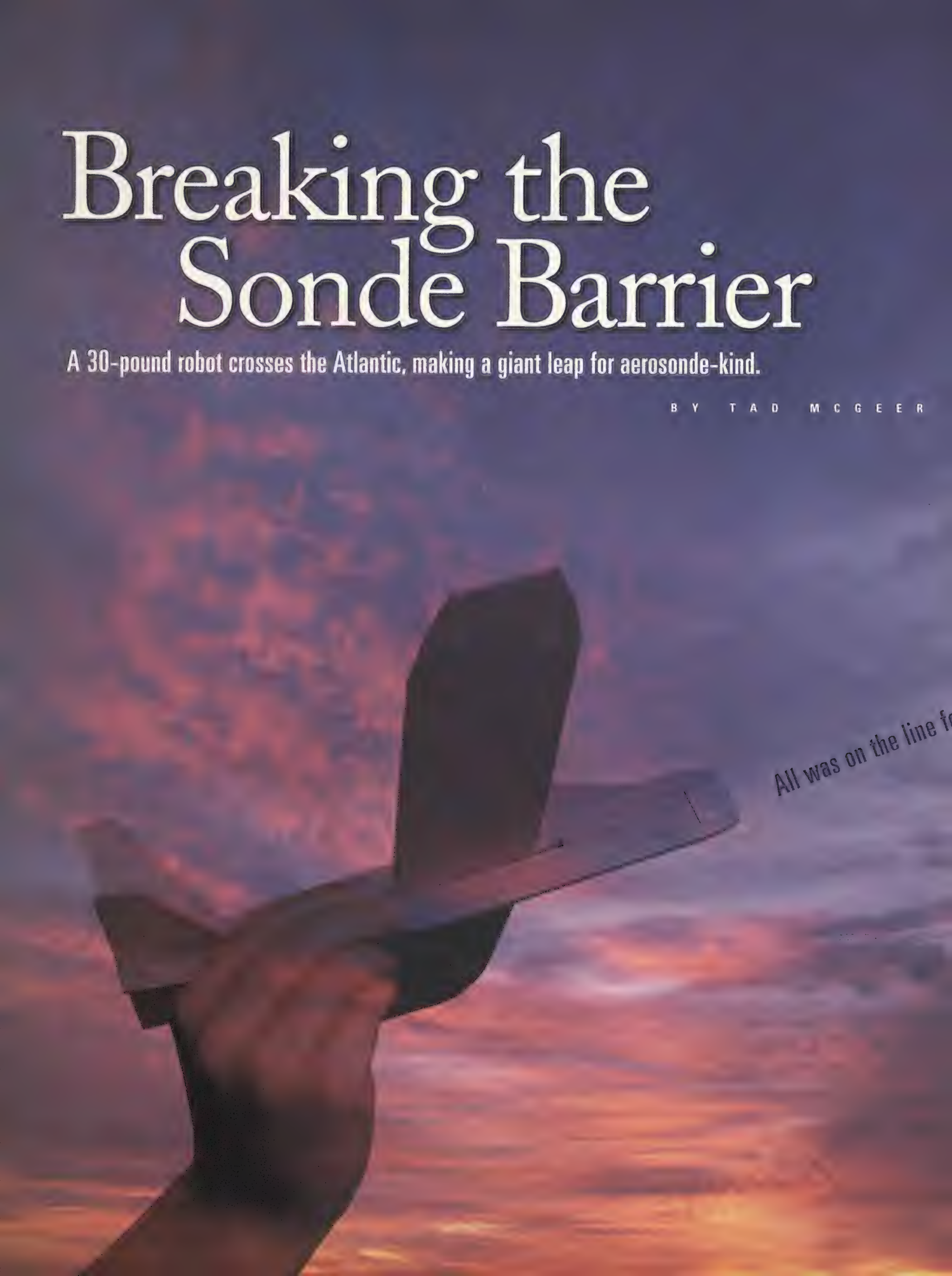


Opposite: A student is tricked into painting a line that will supposedly help him fly straight. Top: The hydroaeroplane on the launching ramp in Glen Head. (At the tail, the water rudder is visible below the air rudder.) Above: The hydroaeroplane just before takeoff.

Breaking the Sonde Barrier

A 30-pound robot crosses the Atlantic, making a giant leap for aerosonde-kind.

BY TAD MCGEER



All was on the line fo

"Maybe it's time for a stunt." My old Stanford classmate, Andy von Flotow, eyed the globe in his hand. We were chatting one night in February 1998. I had just returned from Western Australia, where the aerosonde, a diminutive unmanned aircraft on which I had been working for six years, was being tested. The aerosonde was conceived for long-range weather monitoring over the oceans, but the range of our trials was limited by lack of over-the-horizon communications. While we waited for emerging satellite-relay systems, we had to stay within a hundred miles or so of a ground station if we wanted to send commands and monitor data from our aircraft. But Andy was proposing that we ignore the restriction. He was suggesting that we cross the North Atlantic.

Though introduced as a topic for idle conversation, the idea was feasible. Westerlies blowing across the Atlantic put Europe well within reach for an aerosonde flying from Newfoundland, and we wouldn't actually need to communicate with it en route. We could simply program the route into the aerosonde's computer, launch it, and wait for it to materialize at the other end. This was not, however, an attractive way to do flight testing, and the whole idea seemed pretty farfetched. Yet over the next few days I couldn't let it go. If the idea seemed farfetched to those of us who had built the aerosonde, then it would look enormously more so to prospective users, regulators, and air traffic controllers—the people we wanted to understand what new unmanned aircraft were capable of. Sooner or later we would have to make our case. Maybe it *was* time for a stunt.

"The preposterous illusion that one of our puny toys would survive out there beyond the edge of the world."

There was nothing new about unmanned aircraft, but the concept of nonmilitary unmanned aircraft—particularly very small aerosondes—routinely flying over long distances was novel and challenging. It had grown out of a combination of need and technical opportunity. The need arose from the dearth of meteorological data from over the oceans. Although satellites generate much useful information, forecasters and their numerical models depend on data that satellites cannot supply: soundings of temperature, pressure, humidity, and wind from the surface to high altitude. Meteorologists use balloon-borne radiosondes or parachute-borne dropsondes to take these soundings, but to launch them at sea, large and expensive ships and aircraft are needed, so weather services cannot afford to gather much data offshore (see "Tomorrow's Storm," Aug./Sept. 1999).

Miniature components, especially Global Positioning System navigators, created the opportunity for a much more economical solution. They made it possible to build a miniature aircraft for atmospheric soundings capable of reaching almost anywhere over the oceans or remote land areas and returning data via satellite to weather forecasters. The development of that idea was financed by the the Australian Bureau of Meteorology and the U.S. Office of Naval Research, with the weather services of Canada, Taiwan, and the United States adding their support as the project proceeded.

Our program emphasized development through field trials, which my company, The Insitu Group, began in 1995. By mid-1998, several months after our first conversations about an Atlantic crossing, around 30 prototype aerosondes had accumulated several hundred flight hours in offshore trials around the Pacific. We had demonstrated their ability to collect sounding data in conditions ranging from frontal rain and icing off the British Columbia coast to wilting humidity and fierce thunderstorms in tropical Australia and the South China Sea. We had deployed with relative ease (especially with the aircraft boxed up as part of our airline luggage) and stayed in the air for a long time, with two flights of more than 30 hours and several more exceeding 24 hours. But these results were known only to a small community of engineers and meteorologists.

Were we ready for the Atlantic? In pushing for early field trials on a limited budget, we had foregone the painstaking detail design needed to achieve reliability. While the aerosondes had the range to cross the Atlantic, there was doubt about keeping all the parts together long enough to make a crossing. But in reviewing our failure data, we figured that with three aircraft we'd have a 90 percent chance of at least one going all the way. Stacking up the benefits of success against a cost of $25,000 per aircraft, we decided that the Atlantic was worth a shot—especially when

RON BENNETT



Dwarfed by members of its ground crew, the aerosonde has a 10-foot wingspan and a fuselage about the size of a breadbox.

Shortly after takeoff, the nose dropped straight down and Piper disappeared behind the cliff

the risk involved someone else's money. The project was backed by the Office of Naval Research and by our collaborators at the University of Washington. With their support I started to seriously evaluate our chances in May 1998.

Steve Lord, a computational meteorologist at the U.S. National Centers for Environmental Prediction, confirmed that we could count on the necessary tailwind: Average winds in July and August blow at about 15 mph straight from Newfoundland to Ireland. Cliff Mass at the University of Washington, looking in detail over several years of records for altitudes around 5,000 and 10,000 feet, expected several opportunities per week with good winds at altitudes below the freezing level (which we would not cross for fear of icing).

Was our idea safe? There were hazards to weigh: hitting another aircraft, hitting a ship if the aircraft went down, or hitting something on land if the aircraft went off course. We weren't too concerned about the last problem: Aerosondes have range-safety provisions that will cut the engine if track can't be maintained, and we had never had an aircraft wander off course. But for collisions, we couldn't do much better than random chance, which I estimated to be less than one in 100,000. That seemed safe enough for a one-time demonstration. We moved to get regulatory approval.

The authorities on the Canadian side had worked with us already on trials in British Columbia, and David Wall of Transport Canada made arrangements for departure from Newfoundland. We decided to fly from the Bell Island airfield, on a cliff hard by Conception Bay, a few miles west of St. John's. It offered a route straight into the Atlantic clear of land and air traffic. Transport Canada issued the obligatory Special Flight Operations Certificate in July.

On the European side we were on less familiar ground. We opened discussions with the Irish Aviation Authority in May, and meanwhile searched for a landing site—eventually converging on Belmullet in the far northwest. But the effort was for naught: After months of review, the Irish authorities decided they couldn't accept the lack of en route position reports, or the idea that an aircraft might come across the coast unannounced. They would not admit aerosondes into their airspace.

Another hundred miles would take us to the Western Isles in Scotland. We had already been discussing our crossing plans with Scottish air traffic controllers, who, with Irish controllers, are responsible for the eastern half of the North Atlantic (Gander covers the western half). It turned out that we had to stay below their airspace, at 5,500 feet, since international rules would otherwise call for hourly position reports. But while they couldn't let us fly as high as we'd like, they were happy to help in other ways. When I called Mike Ankers at Prestwick Centre to raise the possibility of landing in Scotland, he responded instantly. Ten days later, everything was laid before us: a landing site at the Benbecula Ranges in the Outer Hebrides, facilities on the ground, arrival procedures, authorization from the Civil Aviation Authority, and terminal weather forecasting from Royal Air Force Strike Command.

KEITH GOSSE (3)





The Bell Island crew prepped Trumper at the local airstrip. Bystanders were warned that the aerosondes, being prototypes, should be trusted only as far as it takes to run for cover.

We completed the plan in the first week of August. It called for terminating the transatlantic route in a holding circuit 10 miles off South Uist island, with our ground station responsible for commanding the aircraft ashore from there. (This would preclude unannounced crossing of the coast in the event of radio failure.) It also required us to enter United Kingdom airspace a bit north of the direct route from

a rolling dive—followed in a couple of seconds by the sickening thump of impact in the water.

Newfoundland, and to fly the 100 miles or so from the entry point to South Uist at an altitude of only 400 feet—thereby allowing aerosondes to qualify as model aircraft, under a sympathetic interpretation of air regulations.

The authorizing fax arrived from London on August 10, a Monday. Our gear, including aerosondes Piper, Trumper, Millionaire, and Laima, left for Newfoundland that afternoon, and the landing party—Bill Vaglienti from Insitu and Steve Huffman and Greg Lipski from the University of Washington—flew to Scotland the next day. My job was at the Newfoundland end, along with Ross Hoag and Kip Jackson, also from Insitu. Thus on Friday morning, flying up from Halifax, I gazed out across the Atlantic, placid but immense and forbidding. I had by then caused tens of thousands of dollars to be spent, and compounded that investment with the efforts of people on three continents, and now it was all on the line for the preposterous illusion that one of our puny toys would survive out there beyond the edge of the world.

That afternoon, I browsed the St. John's Wal-Mart for a couple of jerry cans to fuel our transatlantic fleet. Next, presenting myself at the airport Esso in hopes of actually buying some aviation fuel, I was eyed suspiciously. Company policy, for some unexplained reason, took a dim view of customers with five-gallon cans. I tried to imagine a way to establish my bona fides, but saying that I needed the fuel to fly across the Atlantic seemed unconvincing. Stymied, I retreated to Shell, which had no qualms about how its customers carried off their purchases. With my hard-won gallons I took the ferry to Bell Island.

Sunday promised superb weather. We planned to launch Trumper and Piper. If either was successful then we would be done; otherwise we would send Laima at the next opportunity. We worked through Saturday to be ready for a dawn takeoff, but a snag arose. Numerical wind forecasts, which we had been getting from the Web for months, were suddenly not updating, and without them we couldn't do route selection and itinerary calculations. The problem was traced to a crashed disk on Steve Lord's computer. He worked into the wee hours Sunday morning to put it back online, and with the weather holding we set our sights on Monday morning.

We rose around four. The flight plan had been e-mailed from the University of Washington, where the route had been planned the night before. I transcribed it for Trumper's onboard computer, with a final simulation of the flight to be sure that the program was correct.

Tension mounted as we reached the airport, but the familiar drill kept us moving through launch preparations. A crowd of Bell Islanders gathered to watch the proceedings. As the time for engine start approached, Kip and Ross signed Trumper's fuselage. My talisman was in the avionics bay, a set of pilot's wings given me years before by John Blackmore, a Spitfire pilot and exemplary headmaster who had been a friend and flying companion since grade school in Vancouver. He had died just months before, and Trumper was named after one of his beagles, which is about as much of a memorial as he would have countenanced.



Aerosondes were launched by remote control from a cradle atop a car that drove down the runway.

I addressed the audience briefly, with thanks and a word of advice that Trumper, being a prototype aircraft, should be trusted only as far as it takes to run for cover. Everyone dutifully retreated behind the cars parked off the airport road. We checked communications on the runway, and, while there were hints of a capricious fading we had seen during a test flight the day before, they seemed small enough to be manageable.

We launched on schedule shortly after seven, and flew over the field for a few minutes to verify that Trumper was performing normally. Then I had only to key a new waypoint on my laptop, and it would start along the programmed track to Scotland. My fingers hesitated while Ross and I considered the moment. We decided to go.

Trumper was out of sight in a trice. We tracked it on the laptop, switching to a longer-range antenna as it moved down Conception Bay, and finally lost the signal abut 25 miles from Bell Island. All of our telemetry indicated that Trumper was well on its way.

We waited three hours before launching Piper, to allow for uncertainties in flight times along slightly different routes—and for the ceremony that would surely follow Trumper's landing in Scotland. As we went through the preflight checks, we found that communication fading had become worse. This was a concern for takeoff, which was flown manually, but the autopilot was designed to take charge if manual control was blocked.

Launch was fine, and we had no problem until 30 seconds into the climb. Then there was a communications fade. The autopilot came on automatically, but instead of flying normally, it put the aircraft into a rapid left roll. The nose dropped straight down, and Piper disappeared behind the cliffs in a rolling dive—followed by the sickening thump of impact in the water.

Even more sickening was the diagnosis. After reviewing telemetry and checking the flight software, I realized

Bill looked up from the laptop and there was Laima, brilliant white under scatter

that I had made a mistake in the code. The autopilot was not being initialized properly when it came on automatically (as opposed to the usual enabling by ground command). Often such initialization would be okay, as it had been on the few occasions over the preceding four years when we had had similar blockages of manual control. But I could recall instances on the ground, including those during Piper's preflight checks, when interrupted communication had caused the ailerons to jump. Had I given this a bit of elementary thought we would have saved $25,000 (and perhaps more, had Piper made it to Scotland). The problem could be fixed if we made another attempt, but for now we pinned our hopes on Trumper.

Trumper was due about seven Tuesday morning, Newfoundland time, and I went to bed dead tired, with the hope of someone shaking me awake, red-hot telephone in hand. When I eventually woke, just the daylight in the room told me that hope was already faint. We stuck it out through the morning, the phone silent except for the odd caller wanting the latest report. Eventually Bill Vaglienti rang from Scotland wondering how long to stay on watch. After a few hours we pulled the plug.

But we weren't allowed to let Trumper vanish so cleanly. That afternoon we were back on the runway, verifying the diagnosis—and the cure—for Piper's crash, when Bill called back urgently. He had a call about an aircraft fitting Trumper's description, flying low over Stornoway, some 60 miles to the north. I was skeptical, but Bill had to investigate quickly; meanwhile I rechecked the flight plan to make sure that I hadn't sent it to the wrong place. Presently Bill called back, having boiled the commotion down to only one report describing something at all like an aerosonde—and we had to stack the probability of a mistaken witness against that of a combined failure of both navigation and range safety, compounded by flight

KEITH GOSSE (2)



The author, in a van doubling as a ground station, notes Trumper's vital statistics in a flight log just before the aerosonde took off (opposite).

endurance beyond expectation, and by some byzantine evasion of the mountains between Stornoway and the ocean. We decided just to leave a telephone number with the local police. On Wednesday we received yet another in-flight report, now more than two days after launch. Trumper, it seemed, had transmuted into a robotic Flying Dutchman.

On Wednesday, weather precluded another attempt, with the Hebrides even more dismal than usual, rain in Newfoundland, and poor winds en route. But Thursday looked promising. Laima was on deck, hopefully backed up by its namesake, the ancient Latvian deity of good fortune. Our eyes also wandered to Millionaire. It was one of the original 10 aerosondes, built for our first Australian trial (and named, following a dinner at Gilligan's in Darwin, after a character on "Gilligan's Island"). We had brought it to Newfoundland for parts and test flying, rather than for an Atlantic attempt, but we fitted it with the last of our batch of hand-picked Atlantic engines, and got two aircraft ready for the morning.

We ran up impressive phone bills as we tried to coordinate the farflung flight planning operation. By afternoon Wednesday, planners at the University of Washington in Seattle were offering a route south of the great circle through a front around a mid-Atlantic high. The estimate was about 26 hours en route—not as fast as Monday's plan, but fast enough. And the Friday weather in Scotland was expected to be tolerable. There would be rain over the ocean, but based on our experience in British Columbia downpours, rough weather would not be a problem.

On Thursday we repeated the predawn launch preparations. First light at the airport showed good weather, with high clouds and moderate winds and a crowd of islanders. We launched just before 7:30. Overhead checks were fine, and then it was again time for the few keystrokes that led off to Scotland. By 7:40 Laima was out of sight. We tracked it down the bay, flying at an altitude of around 1,000 feet above the water until clear of the coast. The air was smooth, the wind west at the forecast 17 mph. Half an hour later we lost contact off Cape St. Francis, with Laima running as well as we could wish.

Three hours later Millionaire went down the same track. Performance was similar: Millionaire's signal vanished at 11:20, at the same point where Laima had gone. The long wait began.

First thing Friday morning I checked itinerary updates, which had been calculated overnight by Australian colleagues using the latest wind forecasts. Laima's arrival at the holding circuit was expected about 10 a.m. Newfoundland time, so contact with the ground station was likely between 9:30 and 9:45. Bell Island bonhomie had kept tension at bay, but now our hosts were joining us in tightening like drums as the clock ticked down.

Ross and I had freight to ship home, and we lined up for the ferry to St. John's. I paced by the quay, thinking about likely arrival times and the phone in my pocket. At 9:40 it rang; the timing was full of promise. The voice at the other end was classic NASA controller monotone: "This is Bill. We are in contact with Laima." Elation.

umulus sweeping in from the Atlantic. Touchdown was a gentle plop in the tall grass.

For the crew in Scotland, a week of desolate waiting had built to a taut crescendo. A few minutes earlier, Laima had made a periodic S-turn to measure wind. This oriented the UHF antenna just well enough to make brief contact with South Uist at extreme range. The ground station laptop, which had been torturing the crew for hours with impassive silence, suddenly piped up with a beep and a new color to show active communications. Then nothing. "Was that Laima?" Bill insisted that it couldn't be anything else, but there were five long minutes of electrified tension before the oracle spoke again. Then Laima burst onto the screen, downlink in full cry from 30 miles offshore, and the control room exploded in celebration.

With communications established, Greg Lipski went through the arrival checklist, uplinking the new waypoints necessary to bring Laima onshore. It slipped in past the surveillance radars on Benbecula and St. Kilda islands (where observers, despite knowing where to look and trying hard, didn't see a thing), crossed the beach, and entered a circuit of the landing field. Control was then switched from Greg, perched in an elevated blockhouse inland from the landing field, to another ground station set up for manual control in a battered Land Rover beside the landing field. Bill, standing outside, looked up from the laptop and there was Laima, brilliant white under scattered cumulus sweeping in from the Atlantic. He quickly selected manual control and wheeled it steeply into the chill 25-mph breeze. "ENGINE OFF!" Two keystrokes from Steve Huffman



stopped the propeller for landing. Touchdown was a gentle plop into the tall grass of Scotland—whereupon, as Eric Sorensen of the *Seattle Times* later wrote, "researchers and a handful of onlookers erupted in cheers and hugs."

"We have something you lost," said Bill, back on the phone as our ferry pulled into the dock. We drove to St. John's in a state of total relaxation. Even Millionaire's arrival time came and, sadly, went, with only a faint echo of the morning's worry. It was an honorable final flight; on that day, for us, there were no disappointments.

When Bill next called, we were traveling back to Bell Island and there was more information on Laima. The nose boom, for measuring static pressure, had snagged in the tall grass and ripped out on landing, but that was incidental. More remarkable was a load of rainwater found sloshing in the avionics bay. We had been doubly careless. First, having run out of our preferred tape for sealing the wing to the fuselage, we had used a poor substitute that the rain had undermined, and second, we had not made a drain hole. Laima's Latvian luck had been with it all the way.

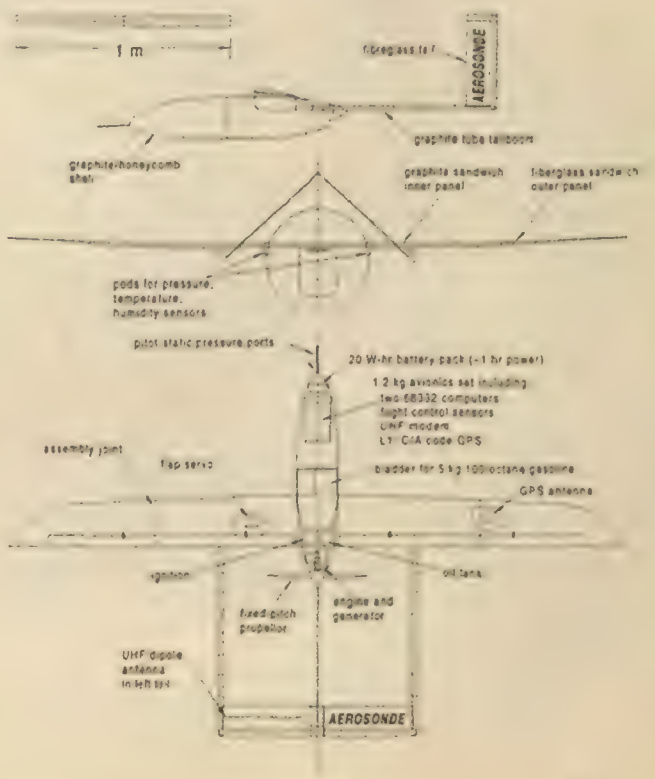
Our gamble had paid off. Laima arrived in Scotland within three minutes of estimate, having covered 2,030 miles in 26 hours and 45 minutes on 1.5 gallons of gas. The media reported the success far and wide. Where previously the idea of long-range operations by miniature robotic aircraft had been esoterica, now it was fact. In the collegial circles of meteorology and aviation, the possibilities for routine ocean weather service suddenly seemed a lot more real and a lot less expensive.

Some Assembly Required

Laima shares the twin-boom pusher layout common to many unmanned aircraft, with an inverted V-tail designed for convenience rather than for aerodynamic advantage. It was built as a testbed, without the refinements of a mature design. The 30-pound structure is composite, including graphite, fiberglass, plywood, and balsa. It is powered by a highly modified 20-cubic centimeter single-cylinder, four-stroke Enya 120 model aircraft engine.

Laima crossed the Atlantic through a series of waypoints chosen to take best advantage of forecast winds. The route was planned the day before launch, and waypoints and altitudes were stored in the onboard flight computer before takeoff, which is remotely piloted from a launch cradle on the roof of a moving car. An autopilot takes over 30 seconds after liftoff. A UHF antenna in the tail enables two-way communication within about 30 miles of a ground station.

Laima's lightweight GPS, the key enabling component of the long-range aerosonde, provided updates twice per second, and with each update the autopilot calculated a steering command to maintain track, which was typically held within a few feet. It also adjusted elevator and throttle to stay on the programmed altitude and maintain an airspeed of about 50 mph.



Rehab for Rockets

Can old ICBMs become cheap satellite launchers? Logic says yes. U.S. policy says no.

by Preston Lerner

UCLA space physics professor Paul Coleman, hoping to cash in on the so-called peace dividend, is looking for a deal on ICBMs. Yes, intercontinental ballistic missiles.

As president of the Maryland-based Universities Space Research Association, Coleman has spent much of the last 10 years looking for a cheap ride to space for academic satellites. Currently, it's impossible to launch even a small commercial payload on a U.S. rocket for less than $15 million. Surplus ballistic missiles, Coleman argues, could become a new class of small, low-cost launch vehicles.

At the moment, just such a vehicle is coming together at a launch pad at Vandenberg Air Force Base in Southern California. The Air Force, which is developing the rocket through its Orbital/Suborbital Program (OSP), has dubbed the launcher the Minotaur. As befits its name—the Minotaur is a Greek mythological creature with the body of a man and the head of a bull—the OSP launcher is a hybrid. Its bottom two stages come from a Minuteman II, a silo-based ICBM whose conceptual roots date back to the years when Richard Nixon was *vice* president. The top two stages are from Orbital Sciences Corporation's Pegasus XL, a commercial rocket first flown—launched from an airplane—in 1996.

"We're looking to give our customers the cheapest, most reliable ride to orbit possible," says Air Force Major Steven Buckley, the program manager. "The idea is to take ICBM assets, which we've already paid for, and turn them into space launch vehicles."

On October 4, after two years of development centered at Kirtland Air Force Base in Albuquerque, New Mexico, an OSP Minotaur carrying five small research and military satellites is scheduled to lift off from the California Space-



Russian missile technology for sale: A Start-1 launcher, derived from the SS-25 ICBM, rolled out in March 1997.

port at Vandenberg. Besides being the first launch from the privately owned and operated facility, the Minotaur will also become the nation's cheapest orbital space launcher. Paul Coleman's dream of a missile-based low-cost ride to space would seem to have been realized. Except, that is, for the fact that government regulations prevent operators of many academic satellites from buying rides on the Minotaur, and the launcher upgrades necessary to meet the needs of its major client—the Department of Defense—have pushed the cost far out of Coleman's range anyway. When the preliminary work was done five years ago, the per-launch cost of a Minuteman II system was projected at $4 million. Now, Buckley says, it will run from $12.5 to $15.5 million. "That's not that much cheaper than a Pegasus XL," Coleman says, "and the payload isn't that much greater."

How did it get so expensive? In a word: politics. Right now, the only commercial launcher catering specifically to under-500-pound satellites is the Pegasus XL, and at $15 million per launch, the ride is often more expensive than the payload. Before the Pegasus came along, small-satellite operators could only hitch rides on more expensive rockets, and at prices far higher than $15 million. It didn't take a rocket scientist to realize that obsolete ballistic missiles, while no longer cutting-edge, could be modified to do the same job at a fraction of the cost. The problem with the Minotaur program is that people spent too much time arguing about it and the price steadily ratcheted up. Meanwhile, the government began imposing strict limitations on who could buy rides on the rockets.

Never Met a Missile He Didn't Like

In the late 1980s, Coleman began pursuing Poseidon and Trident submarine-launched ballistic missiles. After being rebuffed by the Navy, he set his sights on the Spartan anti-ballistic-missile missile. "We actually got the Army to sign them over," he recalls, "but the Army couldn't find the inert parts—the fins and fairings, for example—that are attached to the motors." Having struck out twice, Coleman threw his support behind the Air Force's Multi-Service Launch System (MSLS), the precursor to the OSP program, which was projecting orbital launch costs of a scant $4 million. Although estimates ballooned to $8 million as the specifications were worked out, that was still a bargain-basement price.

Under the MSLS program, Lockheed Martin was contracted to adapt demilitarized Minuteman IIs for several orbital and suborbital missions. Seeing the project as unfair competition for its Pegasus, Orbital Sciences officials complained bitterly to Congress that using government assets to build a cut-rate rocket would price the private sector out of the small-launch market. The Clinton administration listened and, despite Coleman's pleas, killed the most powerful version of the orbital MSLS launcher and, in 1994, modified the National Space Transportation Policy to prevent surplus ballistic missile assets from being used to launch anything but government—or government-funded—payloads. While many academic satellites receive at least some government money, and thereby qualify, those that don't are left stranded. (And those government-funded research satellites that can't afford U.S. launchers have no recourse—they can't go to foreign launchers because of policies regulating the export of satellites.) "They [Orbital Sci-

Under military guard at Svobodny Cosmodrome in Siberia, the Start-1 was developed by an offshoot of a state design bureau.



ences] really knew how to work inside the Beltway," Coleman says. "I'd just fallen off the hay truck."

Left with only one MSLS orbital launch configuration, the Air Force took a harder look at its projected performance. The numbers were discouraging—a throw weight of 150 pounds to 350 miles, far short of the 780-pounds-to-350-mile minimum standard that Buckley knew his Department of Defense clients' satellites would need. "At that point," Buckley says, "I lobbied hard to say 'I'm sorry, it's just not going to meet the needs of our customers.' My leadership agreed with me, and OSP was the result." When the contract was rebid, Lockheed Martin chose not to compete. Later, in a crowning irony, Chandler, Arizona-based Orbital Sciences won the contract to upgrade the missiles, which is a bit like having the fox *build* the henhouse.

Not Your Father's Minuteman

Engineers have actually been turning ballistic missiles into orbital launchers since the dawn of the Space Age. The Soviet Union launched Sputnik in 1957 on a modified ICBM. The Redstone that sent the first American satellite—and the first American—into space was originally designed as a missile. So were the Thor, Jupiter, and Atlas workhorses. Lockheed Martin is still flying the mighty Titan II ICBMs, deactivated during the 1980s. In 1986, the company won a $659 million contract to refurbish and launch 14 Titan IIs, which launched 10 Gemini astronauts into space in the 1960s. To make the conversion, Lockheed Martin modifies the forward structure of the Titan II's second stage to accommodate a payload, manufactures payload adapters, refurbishes rocket engines, upgrades guidance systems, and integrates the payload. Each Titan II—with no additional stages—can lift up to 4,200 pounds into low Earth orbit. Prices for the service average $26 million.

But today's satellite-launching community is different from that of the 1980s—and a far cry from the at-any-cost intensity of the 1960s. In this environment, ICBM conversion is driven more by economics than by convenience, and minimalism is favored over technological wizardry. Still, transforming a missile into a satellite launcher is not as simple as it sounds. While ballistic missiles and launch vehicles share a common propulsion technology, most missiles are underpowered by orbital standards, and thus need, in addition to avionics upgrades, additional stages or strap-on boosters to push heavier payloads into space. This was true of Thors, Atlases, and Titan IIIs and IVs, and it remains true—at least to meet Buckley's needs—of Minotaurs and, to a lesser extent, Russia's current ICBM-based launchers.

The task before Orbital Sciences was really to build a new launch vehicle. What was initially supposed to launch a few hundred pounds a few hundred miles was redesigned to insert a 780-pound payload into a 350-mile sun-synchronous orbit—per the needs of Buckley's mostly military clients. With the additional capability came additional rocket motors, and thus additional expense. In its current configuration, the OSP Minotaur is too big and too expensive for most of the missions Coleman has in mind. But it's just right for the Department of Defense. "If a commercial system, whether expendable or reusable, were suddenly cheaper, we'd clearly go that route instead of the OSP Minotaur," Buckley says. "My role is to provide the mission support

NASM

CHAD SLATTERY PHOTOGRAPHY



Minuteman IIs go from staples of cold war defense, when they were test fired at Vandenberg Air Force Base in the 1970s (above left)...

that my customer needs to put his payload in orbit, and we'll do that in the most efficient way that we can."

From Minuteman to Minotaur

In its previous life, the first and thus far only OSP Minotaur was a Minuteman II housed in a blast-resistant silo at Malmstrom Air Force Base in Montana. Like the other 449 Minuteman IIs once deployed in Missouri, North Dakota, and Montana, it carried a 12 megaton nuclear warhead on top of a stack of three solid-fuel rocket motors. The motors, firing in stages, were able to deliver it farther than 4,200 miles.

Under the terms of START—the Strategic Arms Reduction Treaty, negotiated to eliminate thousands of U.S. and Soviet nuclear weapons—the Minuteman II warheads had to be removed and the missiles themselves "eliminated." They could be launched with dummy warheads, static-fired, or cleaned of the highly toxic, incendiary core of the rocket motors—all expensive propositions. Another option was clearly the best: using the motors for purposes other than delivering nuclear warheads.

In 1993, while Orbital Sciences was lobbying against the use of Minuteman IIs as commercial vehicles, the missiles were pulled out of their holes and hauled to Hill Air Force Base near Ogden, Utah. After they were disassembled, their components were trucked to the Army's Camp Navajo near Flagstaff, Arizona. There they were stored in concrete "igloos," where the temperature and humidity could be controlled. Every now and then, individual motors were shipped out for specific projects. (Minuteman II upper stages are often used to power suborbital sounding rockets used for research purposes and missiles that serve as targets for military missions.) But about 350 usable motors remain intact.

Missile Men

When the Air Force decided to proceed with what would eventually become the OSP program, the Space and Missile Systems Center's Test and Evaluation Directorate got in the act. Located at Kirtland Air Force Base, the Directorate's Launch Test Programs Division is the Air Force's Rocket Science Central. Over the past quarter-century, its people have orchestrated more than 500 launches, mostly of missiles and small sounding rockets.

Buckley was convinced that the 20- to 30-year-old Minuteman II motors weren't going to pose any serious problems, even though they'd been built with an initial shelf-life of five years. "They were designed to protect the country from nuclear attack," he explains. "You can imagine how reliable they are." On the other hand, he recognized that the motors' ICBM pedigree wasn't ideal. To minimize the length of the silos, for instance, the first stage featured four short nozzles instead of one longer but more efficient one. Because the motors are so sensitive to fluctuations in temperature and humidity, special care has to be taken to protect them while they're sitting on the launch pad. Also, since the missile was engineered to carry a robust warhead, the ride to orbit might be too rough for a more delicate satellite. (The OSP Minotaur will be equipped with a payload isolation system that protects satellites from vibration.)

Fortunately, the rockets themselves were in excellent shape. "They had been in the holes for 20 years, but they were stored under ideal conditions and maintained by the best crews," says program manager Larry Bons. "They

...to satellite-launching Minotaurs during a conversion supervised by Air Force Lieutenant Lou Marina.



were very good vehicles to go grab and put to work." After studying the voluminous paper trail that recorded the life histories of the approximately 350 rocket motors that were available, the OSP team selected an M55A1 first stage built in 1968 and an SR-19 second stage built in 1984. The motors were shipped to Hill Air Force Base and CT-scanned to check for cracks in the propellant. Every component was brought up to original production specifications by technicians who've been working on similar motors for 30 years. After reassembling the unit, the technicians tested all major subsystems. The entire process took two months. "It's important to recognize that these rocket motors are not free; they cost us about $500,000 to refurbish," says Buckley. "But if I were to buy [comparable] motors on the commercial market, they would cost on the order of $6 million."

While the bottom half of the OSP Minotaur was coming together in Utah, the considerably more expensive (approximately $12 million) upper half was being assembled at the Orbital Sciences plant near Phoenix. Although the company is best known for its Pegasus XL and Taurus small and mid-size orbital launchers, the engineering team based in Chandler works primarily on ballistic missile programs, conducting tests, research, and development for the DoD. "These guys are real rocketeers," Buckley says. "They're seasoned. Whatever happens, they've probably dealt with it before."

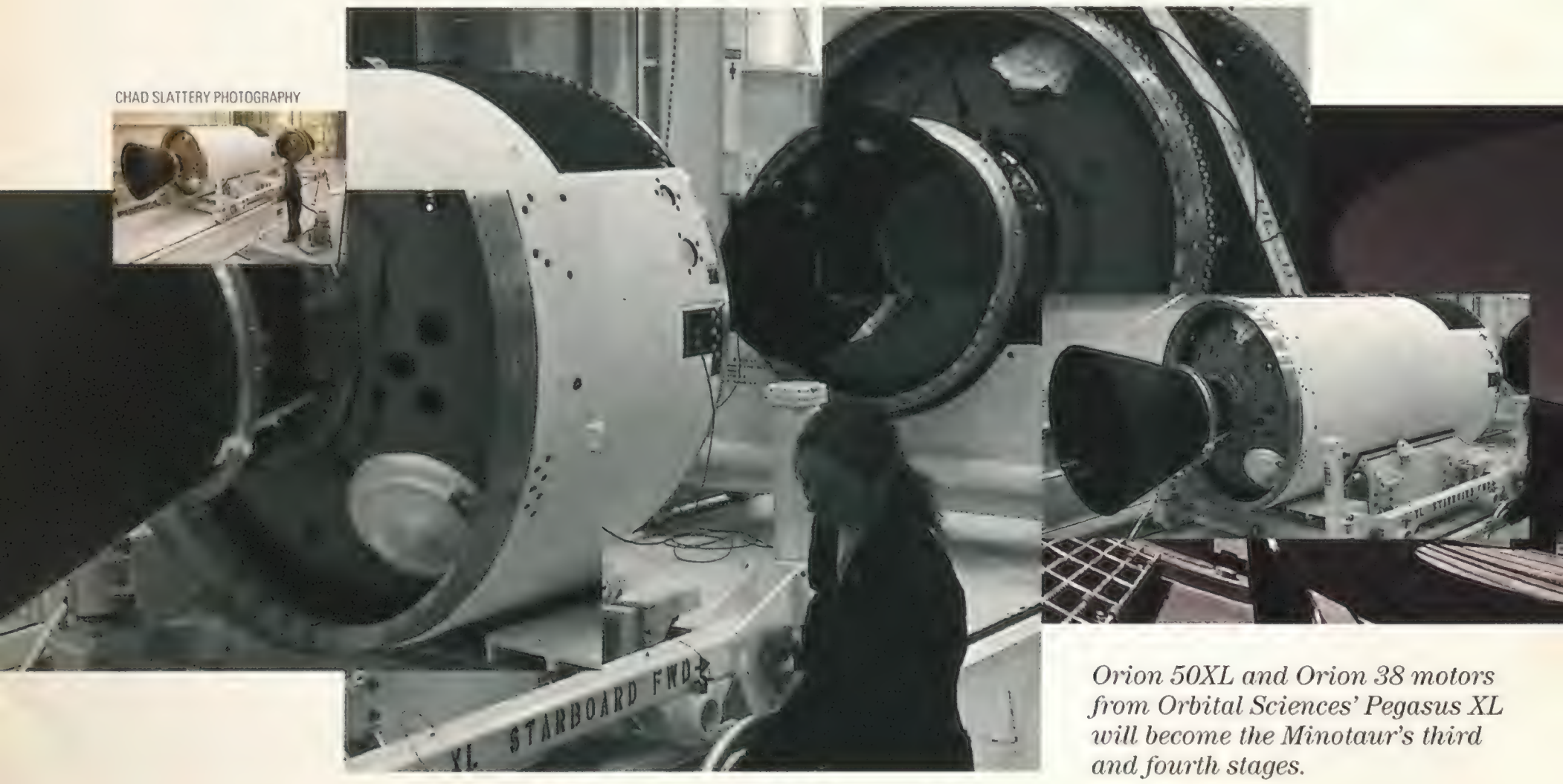
Lead systems engineer Scott Schoneman, a Southern California native, joined Orbital Sciences after a stint launching intercept missiles for General Dynamics. In one form or another, he's been working in the field ever since he was a kid. "I've still got my model rockets in a box in my garage," he says. "So I guess you could say I'm going from building rockets that go up a couple of hundred feet to ones that are going a couple of hundred *miles* up." Schoneman's boss, Larry Bons, has spent 14 of the past 16 years working on Minuteman programs. Like the OSP program, the missions have ranged from suborbital launches of missile targets to orbital tests.

Bons, Schoneman, and the others at Orbital Sciences are providing the Orion 50XL and Orion 38 solid-fuel boosters that serve as the third and fourth stages of the OSP Minotaur. Since these motors (and the basic avionics) are already used in the Pegasus XL, they're known commodities. Although the flight control software was created from scratch, the only piece of hardware that had to be developed for the Minotaur is a simple aluminum semi-monocoque interstage that will connect the Minuteman II and Pegasus XL portions.

Buckley says its first launch will run about $22 million, but this includes all of the development costs. Subsequent flights will be priced at roughly $12.5 million for a small payload to $15.5 million for a full-option large payload. The lion's share of the money—$9.5 million—is earmarked for Orbital Sciences, with a portion going toward the Orion motors, avionics, and other hardware and the rest for vehicle integration, launch services, and the like. These, Buckley emphasizes, are basic expenses. "There are no great strides here, nor should there be," he says. "Our goal is cheap, reliable space lift. You provide that by building Chevy pickup trucks, not Cadillacs."

Still, strolling through the Orbital Sciences plant, it's impossible not to be awed by the complexity of the project. Even that "simple" interstage has

CHAD SLATTERY PHOTOGRAPHY



Orion 50XL and Orion 38 motors from Orbital Sciences' Pegasus XL will become the Minotaur's third and fourth stages.

to be fitted with an elegant spring-and-slide assembly that allows it to separate cleanly in flight when the pyrotechnic charges detonate. Seeing all the pieces that have to be integrated into one virtually bulletproof unit, it's hard to believe that any rockets ever manage to get off the ground, much less fly with the sort of accuracy required to insert a satellite into orbit.

"I'm pretty confident," says First Lieutenant Lou Marina Jr., the mission manager, about the upcoming launch. "Just about every piece of equipment we're using on this rocket has flown before. It all has a heritage." He smiles, adding: "But honestly, we're not going to be 100 percent sure until the time hits zero on [October 4th]."

Buckley, too, has concerns. "What worries me are the unknown unknowns; those are the things that kill you," he says. "Rockets are brute-force engineering. If you don't do your business by the numbers, they blow up on you."

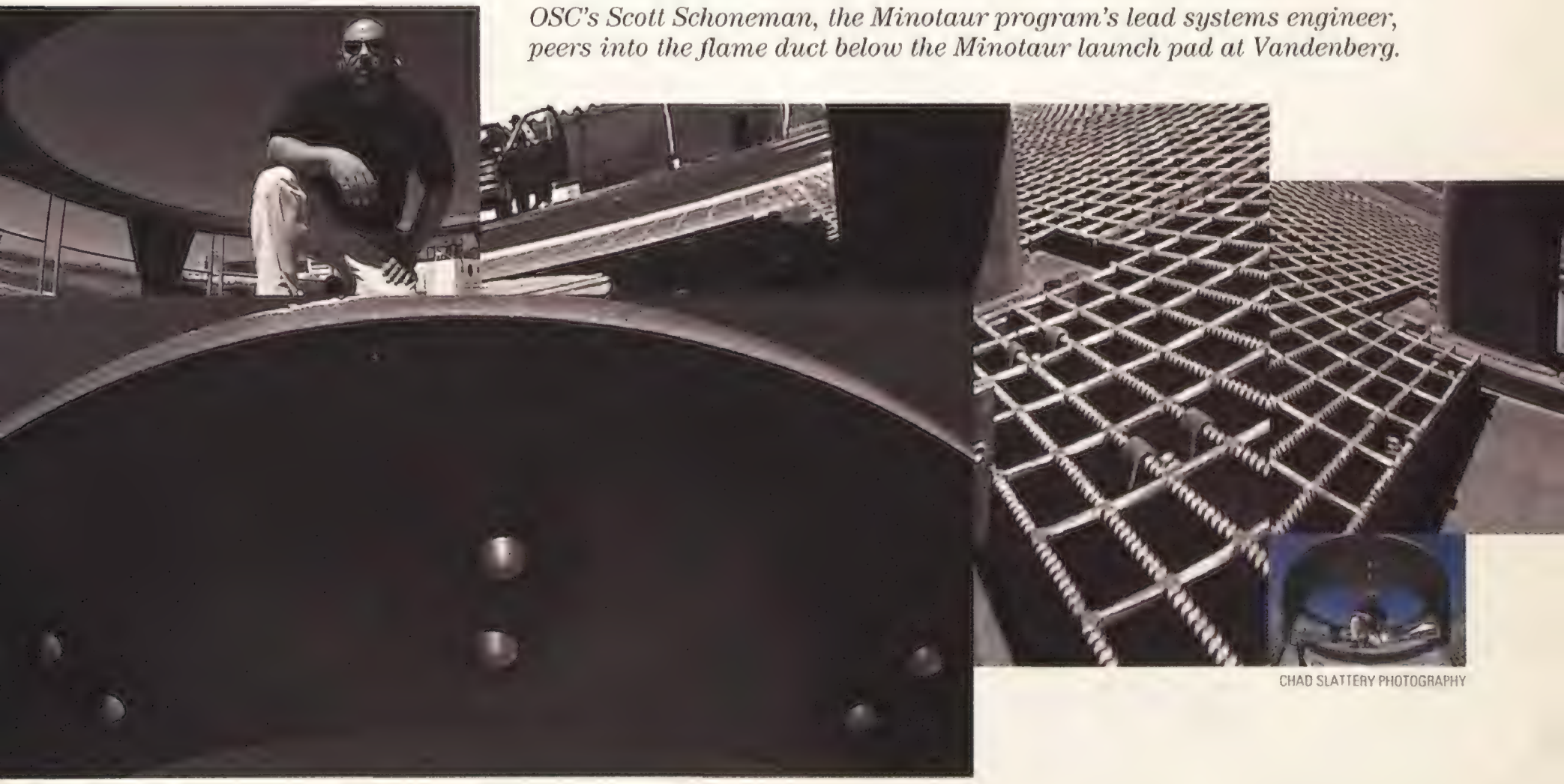
And if everything goes as planned? Well, that may raise as many questions as it answers. For example, the Air Force is currently authorized to convert only five Minuteman IIs into orbital launch vehicles over the next five years. If unused Minuteman II assets exist, why not turn them into Minotaurs? And if Minotaurs are successful, why not use them to provide low-cost access to space to the commercial sector? Some question a policy that promotes one enterprise—the commercial launch industry—at the expense of another—the small-satellite and space research communities. Matt Bille, a space analyst who's written extensively on the subject, says, "I think we're making a considerable error by not allowing ICBM stages to be used for commercial launches. Look at what happened after World War II, when we dumped thousands of surplus transport planes on the market. This didn't kill Boeing and Douglas. The market expanded. I defy anybody to identify a single payload that's gone to a [foreign] launcher because of our policy."

Russia's Rocket Revolution

The same factors that led to the development of the OSP Minotaur in the United States—START foremost among them—are just as compelling, if not more so, in Russia. First of all, space technologies are among the most valuable assets of the sputtering Russian economy. Better still, the government doesn't have to deal with the thorny issue of competition between the public and private sectors because most of the companies plying the space market are privatized remnants of the once-monolithic Soviet space agency. As a result, the Russians are attacking the commercial market with unprecedented entrepreneurial gusto.

The Dnepr, a mid-size orbital launcher derived from the SS-18, the world's most powerful ICBM, successfully launched its first commercial payload, an 841-pound British communications satellite, from Baikonur Cosmodrome in Kazakhstan on April 21. Meanwhile, an offshoot of the design bureau that spearheaded the Soviet solid propellant program has already launched three of the smaller START and START-1 launchers, which are based on—but not converted from—SS-20 and SS-25 ICBMs. These launches cost clients between $9 and $10.5 million. The end of the year should also see the inaugural commercial flight of the ROCKOT, a small (three-stage) but powerful launcher converted from an SS-19 ICBM and marketed by Eurockot Launch Services, a joint venture of the elite

OSC's Scott Schoneman, the Minotaur program's lead systems engineer, peers into the flame duct below the Minotaur launch pad at Vandenberg.



CHAD SLATTERY PHOTOGRAPHY

Khrunichev State Research and Production Space Center and Daimler-Chrysler Aerospace. To launch 100-to-2,000-pound payloads, its customers will pay between $13 million and $15 million. Motorola Satellite Communications of Chandler, Arizona, has signed on as one of the first ROCKOT users. "I can't imagine a better example of turning swords into plowshares," says Bremen, Germany-based ROCKOT mission manager Mark Kinnersley.

There's no doubt that this is an honorable transition for once-deadly ICBMs. The question is whether, under current U.S. government policy, there is a market to support this new breed of small launch vehicles—Russian or American. Because large, expensive satellites continue to dominate manifests, large, expensive rockets continue to dominate launch logs. And with an apparently limited number of small satellites making it into production—U.S. university satellites notwithstanding—the future of these small launchers remains a question mark.

"The market just hasn't materialized," says Larry Foor, a former Orbital Sciences engineer who's now vice president of United START Corporation, which markets the Russian START and START-1 in the United States. Although these launchers can send small satellites to low Earth orbit at hard-to-beat prices, Foor has had trouble drumming up business. "I would have thought that we'd be up to five launches a year by now," he says. "If the U.S. were to drop its policy, this would all change."

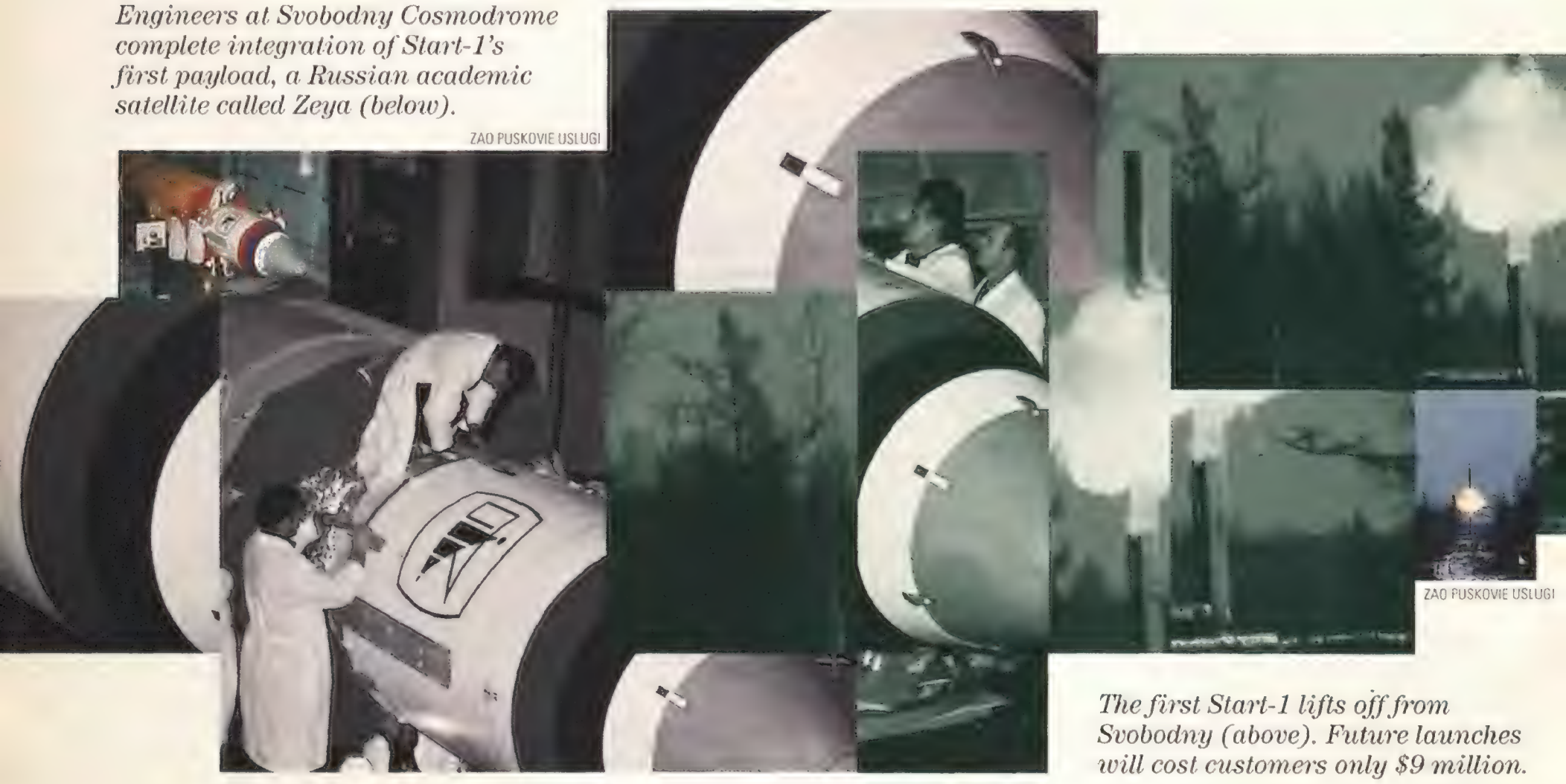
Indeed, Paul Coleman's academic crowd would likely leap at Foor's rockets were it not for policies preventing government-funded satellites from riding foreign launchers into space. So he and his colleagues are still searching for cheap rides. Coleman is disappointed that the once-promising Minotaur has been pushed—by policy and military requirements—well beyond his reach. "Even if you divide the Minotaur up and launch several satellites, it's still going to cost at least $6 million, which is too much when you consider that it's not uncommon for an entire academic mission, not counting the launch, to only cost $4 million," he argues. "But we believe that if the prices come down, more missions will be developed by universities and commercial businesses."

Coleman's colleague Supriya Chakrabarti, an astronomy professor at Boston University and director of the Center for Space Physics, agrees, adding that low-cost launchers are, in fact, key to sustaining all types of research. "Every time NASA puts out an 'announcement of opportunity,' they get about 50 proposals," he says. "Of those, about 10 are exceptionally well researched, and only two actually fly. So with every announcement, you're creating eight losers instead of more winners. We can't fund or support many good ideas, and that has a demoralizing effect." This, he adds, applies to both academic and commercial science endeavors. For commercial organizations, the Russian ICBM derivatives are cheaper to launch, but they still carry substantial costs associated with remote launches.

For the record, there are several launch vehicles in various stages of development that purportedly will offer cheaper access to space. Then again, no rockets are faster, cheaper, or better than the ones that are still on the drawing board. If the Minuteman II could be scaled to Coleman's original needs, it would boast two colossally persuasive selling points: It's not made out of paper, and there are plenty more where it came from.

Engineers at Svobodny Cosmodrome complete integration of Start-1's first payload, a Russian academic satellite called Zeya (below).

ZAO PUSKOVIE USLUGI



ZAO PUSKOVIE USLUGI

The first Start-1 lifts off from Svobodny (above). Future launches will cost customers only $9 million.

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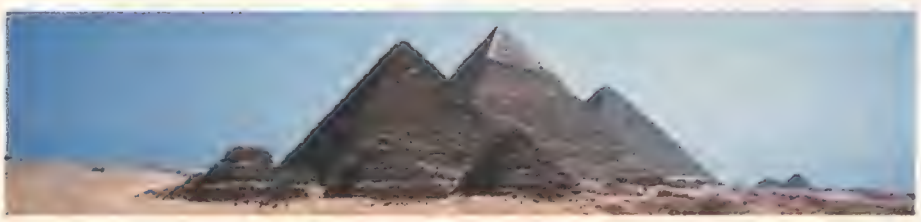
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Frankfurt, Germany	FRA
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THE LEGENDS





With names like Beryl Markham and Denys Finch Hatton on the roster, today's members of the Aero Club of East Africa have a reputation to live up to.

by Debbie Gary Callier *Photographs by Tim Wright*

We fly over small lakes dotted pink with flamingos, past Masai villages and thermalling vultures, past steaming geysers and long-dead volcanoes. A smoldering grass fire flows up the valley like lava. This is the Great Rift Valley of Kenya, the Cradle of Mankind, a place whose harsh beauty and hostile countryside have drawn adventurers, hunters, and admirers for centuries—and pilots for most of this one.

We touch down in Nairobi at the venerable Aero Club of East Africa, a Kenyan institution founded in 1927 by some of Africa's earliest aviators. The club is a gateway to the African wilderness. It sits by the runway of Nairobi's Wilson Airport at the edge of the Athi Plains, with the tall buildings of Nairobi at its back and the wild animals of the national game park in its sights. It is also the heart of aviation in Kenya, a landmark whose list of past members includes 1930s aviator and author Beryl Markham and pilot Denys Finch Hatton, a paramour of novelist Karen Blixen (a.k.a. Isak Dinesen). It is still one of the best meeting places in the world for all who love flying.

The club's current 500-plus member roster is varied, ranging from commercial and private pilots, mechanics, airport officials, and airline personnel—Wilson Airport is the city's second largest airport—to a broad range of aviation enthusiasts, both men and women, both black and white (though mostly white). "Membership really entails drinking with kindred spirits in the bar over a game of pool, in the dining room, or on the squash courts," explains manager and aviation enthusiast Alasdair Sinton, who came to the club in 1958. The center of this socializing is the modest single-story clubhouse, which features a bar, dining room, pool room, and outdoor patio. A swimming pool is nearby, and visitors have access to six barracks-style guest rooms. Six more are under construction—this time deluxe models that will sport ceiling fans, hair dryers, televisions, and nice wood floors.

Conversation inevitably centers on the true focus of the club's activities—flying, whether it's sport, pleasure, or business and whether the participants have spent a lot of time in the air or



Aero club member Alan Binks flies his Cessna 185 over a lake in the Rift Valley (left), about a 20-minute northeasterly flight from Nairobi. Back at the clubhouse, an inverted piston doubles as an ashtray.



ARCHIVAL PHOTOGRAPHS VIA CHRISTIAN STREBEL COURTESY AERO CLUB OF EAST AFRICA

Shortly after her historic transatlantic flight, Beryl Markham prepares to set off in a de Havilland Gipsy-Moth (right). At the Gliding Club of Kenya, an airfield 60 miles north of Nairobi where club pilots try their hands at unpowered flight, Christian Strebel's Piper Super Cub sits in a light rain as the Swiss pilot taxis up in one of his other airplanes, a Cessna 182.

precious little. "There are young chaps here who have done very little flying, but they mix because of the flying aspect," says Bill Armstrong, a member since 1946. "That to me is an aero club. The whole idea is to encourage more and more people to fly." Though the club owned or leased its own airplanes until the 1980s—it went through several Tiger Moths, two Chipmunks, two Cessna Aerobats, and three Rheims Rockets—today airplanes are either privately owned by Kenya's wealthier residents or are rented from Colin Davies of CJ Aviation. Davies charges special rates for club members and for the Pegasus Flight School, where members can take lessons at bargain prices. Annual dues—up to $160—also entitle members to use the club facilities, which are supported by a full-time manager and staff.

The primary activities of the current members—flying and socializing—have been preoccupying members all the way back to 1927, when 24 pilots and would-be pilots joined ranks to form the club. They were an interesting lot. The earliest roster reads like the seating chart for a state dinner: Lord Delamere, Colonel A.C.E. Marsh, Major C.A. Hooper, His Excellency Sir Edward Grigg, Commander L. Mansfield Robinson. Well-known pilots rounded out the list: Thomas Campbell Black, who eventually helped create Kenya's first commercial aviation service, and John Carberry, a wealthy Irish nobleman who owned the only private aircraft in Kenya when the club began—a de Havilland 51 called *Miss Kenya*. These names reflect the two major components of the white population of Kenya, then a British colony: the soldier-settlers who left England to fight for the Empire and never returned, and the aristocrats, the younger sons of titled families who left their birth homes because of primogeniture laws. (Since only the oldest sons could inherit the family estate, younger sons settled abroad.) They had money and time on their hands, so a few soon followed Carberry's lead and bought airplanes.



While the aero club itself had no airplane to call its own for the first two years, its members weren't fazed. They were there to socialize, share their love of flying with one another, and encourage the government and businesses to support aviation—the same goals that fueled other new aero clubs around the world. In England, the club movement was well under way. Formed in 1924 and 1925 in Brooklands, Croyden, London, and other cities, these clubs offered affordable flying to the masses. Sir Sefton Brancker, the enthusiastic head of British Civil Aviation who sought an air-minded general public as a base of support for future air power, implemented a government subsidy plan to help form 10 flying clubs. New airplanes and pilots spurred their growth. In 1923, for example, the London *Daily Mail* inspired aircraft designers by offering a £1,000 prize for the best light airplane. And the First World War had produced hundreds of ex-military pilots eager to fly as civilians.

In Kenya, the Aero Club steadily gained membership, as well as support similar to that enjoyed by British clubs. In 1929, Nairobi officials leveled ground for a proper airfield, the club built their clubhouse, and Lord Wakefield, a wealthy patron, sent the club a Gipsy-Moth from England. By then the club had 209 members. By 1933, 25 of them had earned flying licenses.

Today, every nook and cranny in the

clubhouse bears evidence of the club's history: photos, propellers, engine blocks, trophies, paintings. Above the fireplace, in the big room that was the original clubhouse, there is a poster-size 1936 photo of Markham, and a 1942 copy of the jacket from her book *West With the Night*. In the photo she looks a little aloof, perhaps because she had just made the first solo across the Atlantic from east to west, an accomplishment that earned her a lifetime membership in the club.

Markham, who died in 1986, was an intriguing woman. Men swooned at her feet, but she didn't hang out in the bar the way many did, writes Markham biographer Mary S. Lovell in *Straight on Till Morning*. The club respected her for her extraordinary flying ability. She was the first member to earn a commercial license through the club. She was ready to fly day or night, and was among the first in the world to make a living spotting game from the air for hunting safaris. Indeed, she and her contemporaries led adventurous lives during the club's glory days, and members influenced one another enormously. Thomas Campbell Black—her flight instructor—the highly respected Finch Hatton, and John Carberry all had an impact on Markham's flying. The first two she loved; Carberry she loathed. People say he had a mean streak, but he also had a stable of airplanes—including a low-wing German monoplane, a Klemm, and a Fokker Universal monoplane—at his private airstrip, and he challenged her to fly them under tough conditions. Her competitive spirit would not allow her to refuse. It was his Vega Gull she flew across the Atlantic.

Campbell Black challenged Markham as well. He coached her to become a skillful pilot and inspired her to make her Atlantic crossing. But his influence extended even further: He taught many club members to fly and created flying jobs as he pioneered airmail routes and, with fellow member Florence Kerr Wilson (for whom Wilson Airport is named), commercial aviation services in Kenya. He set his own record, with C.W.A. Scott, by winning the 1934 London to Melbourne race in two days, 22 hours, and 59 minutes.

Finch Hatton impressed both Campbell Black and Markham with his love of flying and of Africa—as a youth, he declared that England was "too small." He learned to fly in his home country—where primogeniture laws prevented him from owning land—bought a Gipsy Moth in 1929 and shipped it to Kenya. Both Markham and Karen Blixen were enamored of him. Blixen wrote lovingly of her flights with him in the book *Out of Africa*. The book portrayed Finch Hatton as a skillful pilot and hunter who valued his relationships with the Kenyans. Using the aero club as his base, he showed Blixen the broad savannahs with the gamboling wildebeest, the lush forests of the ever-green Aberdares, and the hot, gray hollows of the Rift. He encouraged the storyteller in Blixen and the pilot in Markham.

As the Second World War drew near,



From the cockpit of a light aircraft, the grayness of the Rift seems to give way to the lush greenness of farmland and lakes in Kikuyu Country (top). Back on earth, an Antonov An-2—grounded for years—languishes in the grass at Wilson Airport.



the years of abundant flying and celebrity pilots began to fade. Club flying ceased temporarily in 1939, when the government took over the club airfield and most active pilots left Kenya to join the Royal Air Force in support of the war effort. Several current members, including Bill Armstrong and Mike Richmond, both in their 70s, visited the club then as RAF servicemen. Armstrong, who was the personal assistant to the airfield's commanding air officer, went there every day with his boss. "It was very quiet indeed," he says. "The old aero club chaps hadn't come back."

The club bestowed honorary membership on Armstrong in 1946. He moved upcountry, where he farmed from 1947 to 1963. He still visits the club every day, always impeccable in slacks, a jacket, and an ascot, and with manners to match. He explains the success of British flying clubs: "An air attaché used to say, 'The finest club in the world is the RAF, because you only have to talk for two minutes and you are on the same wavelength. You are talking about airplanes.' You may be talking about a Tiger Moth and he's talking about a Lancaster or a Flying Fortress, but flying brings the chaps together."

Although it formed three years after Brooklands, England's first lightplane aero club, the East Africa Aero Club is one of the few that has operated continuously since then. World War II didn't close its doors completely: When clubs and flight schools all over the world abandoned their buildings for military security in 1939, the members of the African club disassembled their clubhouse and moved it off the airfield—but continued using it—until the war was over. In 1946 they moved it back.

Most members served in the war, but a staff kept the club going. At the time, Armstrong's friend Richmond was a test pilot on the field—he checked out newly repaired aircraft. He has served as club chairman and, for 40 years, as a committee member. During his 18 years of leadership, the club's flight school was a financial success. In the late 1980s, under different leadership, the school floundered, then failed, but the club carried on, building its membership and continuing to serve as an active aviation center.





Today 52-year-old Rory McGuinness is my tour guide flying through the Rift. McGuinness is a private pilot and a thin, blond actor. Born in England but raised in Kenya, he lived here until 1961, when his father, who was also a pilot and a club member, returned the family to England. "We arrived in this murky, cold, dismal, over-crowded place and all I wanted to do was to come back to Africa," McGuinness says. So he did.

However, he explains, private flying here is prohibitively expensive now because of the high cost of fuel, the landing fees, the price of airplanes, and the devaluation of the Kenya shilling. The Cessna 206 we fly belongs to club member Basil Criticos, Kenya's assistant minister for health, who loaned it to us for the day.

We skim the floor of the Rift, then crest the rim of Longonot Volcano and peer down its huge crater, filled with

Crowds examine a de Havilland DH 82 Tiger Moth (top, at left) and an unidentified tri-motor biplane during Nairobi's 1932 Air Rally. Maia Carberry, club founder John Carberry's second wife and the first Kenya-born woman to own and fly her own aircraft, poses with her DH 60 Moth Miss Propaganda *(above left). A Sikorsky S-39 called* Osa's Ark *warms up during the 1932 rally (left).*



a fat, black plug like a bathtub stopper. At the bottom is a crumpled airplane, but McGuinness doesn't mention it. Later at the club, I learn that a sightseeing Comanche circled inside the crater, hit the wall, and slid to the bottom. Hyenas got to the pilot and passengers before rescuers found them.

McGuinness banks over an escarpment and climbs southeast. The stark gray curves of the Rift give way to the neon green squares of Kikuyu Country: homesteads, tea fields, red tile roofs, purple jacaranda trees. On landing, we roll past the Aero Club, a crumbling Antonov biplane, rows of Caravans, King Airs, and Turbo 206s. The field is high: 5,500 feet, an altitude at which the air is thin and only the more powerful airplanes perform well. The nearby grass is tall and the entire airfield is covered by a thin layer of red dust. Soon, the short rains will come and wash down the buildings and asphalt runway. Enormous herds of zebra and wildebeest have already left the Nairobi National Park next door. Escorted by an entourage of predators, they headed south to the Serengeti and will return in several months after the long rains. The airfield is fenced to keep them out.

In the bar, after flying, we order mugs of Tusker and White Cap and listen to 70-year-old Imre Loefler, a recent club chairman who during his tenure focused club efforts on long-distance rallies. He is a tall, dark-haired, chain-smoking surgeon with a thick Hungarian accent. "We are not health conscious," he laughs as the beers arrive and his cigarette smoke drifts out of the ashtray—an up-ended piston. "We drink, we smoke, we do all those things which are forbidden in America." Loefler grew up in Hungary, attended medical school in Germany, did his residency in America, then moved to Africa. He learned to fly 30 years ago and joined the club in 1975.

As a surgeon, he flies long distances to operate in hospitals at remote locations. Ever the pilot, he makes an unusual demand in return for his efforts: The hospital has to build a runway. "I don't like to fly to their airfield, then spend an hour in a rickety Land Rover," says Loefler. So he teaches hospital staff how to build an airfield. "It is easy," he says. "Which way is the wind? Knock down those trees. Then get 200 people with jembes [a type of hoe]. I have built maybe a dozen airfields next to hospitals that wanted me to do surgery."

When Loefler joined the club in 1975, general aviation was in its heyday in Africa. "This was a vibrant flying club," he says. On a whim, people hopped in airplanes to fly south to the Serengeti, north to Ethiopia, west to Lake Victoria, or east to the Indian Ocean. "Flying was cheaper than in America. Everyone had an airplane or was in some way involved in aviation, if not as a pilot, then as a stewardess, as a controller. However, everyone was white, snow white. It was very, very British."

Today most of the black African pilots head out the airport security gate to lunch or drink at Dambusters, a small restaurant near the airport entrance. Only a few come to the club. Oppression and violence are issues that are kept outside the walls of the airport. The British dominated black Kenya until the colony won its independence, peacefully, in 1963, but an undercurrent of hostility remains, sometimes politely disguised, sometimes not. In an effort toward change, current club chairman Michael Duckworth and manager Sinton encourage prominent airport officials to join the aero club.

Samuel Muthami, the airport manager, understands the need to bridge the gap between the predominantly white club membership and the predominantly black airport leadership. Often he comes to the club for lunch. "The club is the only place in Kenya where people in aviation socialize in a free atmosphere," Muthami says. "It could be for fun, but it is more than that. Great ideas are born here. Problems can be solved at a table."

Tonight in the bar the power fails

Socializing at the club takes place mostly in the Daddy Probyn Bar (below), which is named after longtime member Air Commodore Harold "Daddy" Probyn, who held a pilot's license until he was 93.







Colin Davies repairs aircraft in a hangar adjacent to the club. Overhead hangs Daddy Probyn's Jodel 9, a homebuilt airplane (below left, with Probyn) powered by a Volkswagen engine. Fliers John Alcock and Arthur Whitten Brown, who in 1919 made the first non-stop flight across the Atlantic Ocean, established early air routes in Africa and inspired the club's founders. On the club wall, a photograph of their Vickers Vimy honors their memory (bottom).

and the walls and tables are washed by the watery light of backup lamps. Everyone keeps talking as if nothing happened. I am at a table with Imre Loefler and he continues his story: "In those days East Africa was one entity, the East African Community. So we used to hop in an airplane for lunch and fly to the Serengeti. Then in '77, one day the East African Community fell apart." Pilots could not pass between Kenya and Tanzania without government permission, he says, and several airplanes were "left to rot" in other countries.

Around the bar are men and women from every facet of modern-day East African flying. They include African Medical and Research Foundation (AMREF) pilots, known as the Flying Doctors, who bring injured folks out of the bush, the Kenya Wildlife pilots who roam the parks by air, the relief flying pilots; safari pilots, and just plain pilots who fly for fun.

Young Trevor Jones flies for AMREF. "The other night I landed a Caravan in Sudat, on the Somalia-Kenyan border," he says. He was responding to an emergency call: his organization had gotten word that someone had been shot. "I left the engine running and the lights on. One of my things is that I won't shut down at night in the bush. Then 22 Land Cruisers pulled up; I counted them. Armed men jumped out, surrounded the airplane and the cars. I said, 'What is happening?'

"They said, 'We've just been shot at.'

"I thought, 'Great! here is this Caravan, with nav lights, beacons, and cabin lights on,'" Jones recalls, explaining how he felt himself to be a perfect target. "So I put on the brakes, got out, and sat in the bush 70 feet away to watch them load [the wounded man]."

Another time, Flying Doctor pilot Benoit Wangermez arrived to airlift an injured man. The man surprised Benoit by walking to the airplane, though he stepped gingerly, as if on glass. "What's wrong with him?" Benoit asked. "I thought he was in a tribal clash." They pointed to the man's eye, where Benoit saw a little piece of metal in the corner. "So?"

They said, "Look at the X-ray." Wangermez saw nothing at the end of what he thought was an index pointer. "What are we looking at?" he asked.

"That is an arrow in his head, not an index," replied a medical officer.

Not all club flying is about life and death in the bush. Some is pure fun—the gliders at Mweiga and the balloon safaris in the Masai Mara, for instance. Christian Strebel owns Yellow Wings, a charter company with offices adjacent to the club. Alan Binks leads safaris for Ker and Downey, sometimes in his Cessna 185. In their spare time they fly gliders in Mweiga, 60 miles north of Nairobi. Heading there, Binks skims low over the rain forest of the Aberdare Range, past trout streams and 900-foot waterfalls, buffalo, elephants, and thickets of bamboo.

Coffee estates surround Mweiga, and from the air the bushes are even, round dots. The airfield sits in the shadow of Mount Kenya, a 17,000-foot snow-capped extinct volcano that stands right on the equator. When we land, rain clouds envelop the icy mountain, sending sleds of cold air barreling down its sides toward Mweiga. The gliders soar in it, Binks in a sleek-winged beauty and Peter Allmendingen, who teaches there, in a 1953 Slingsby T-21, a side-by-side open-cockpit glider.

Another day, at sunrise in the Masai Mara, our shadow runs in front of us and club member Don Weiler, 53, our Balloon Safari pilot, talks in whispers. As 12 of us lean over the gondola's



sides, Weiler manages the burners. The wildebeest kick up their heels like donkeys. Cape buffalo run into a thicket. "The buffalo are residents," Weiler says. "When the wildebeest are gone, the lions turn on them."

One of the passengers is Oly Tomy, a young Masai man who works for the Keekorok Lodge. His job is explaining the Masai culture to the tourists. Today he is just along for the ride. Tall and thin, he is wrapped in a red blanket against the morning chill. His earlobes are long and open, like bracelets. They hang well below his chin. "The buffalo is the only animal that kills for sport," he warns us.

At sunset the night before, a line of wildebeest stretched single file from one horizon to the next. Two Land Rovers sat on one side of them like motorists at a train crossing. In front of a bush a lioness guarded a wildebeest carcass while a spotted hyena and a silver-backed jackal paced.

Back at the Aero Club the bar fills up for a party—but apparently not one of its biggest. "This is nothing," Benoit Wangermez says. "If you had come here in '93, '94, you could not have gotten through the door. In '91, when Somalia exploded, the place was booming with relief pilots from South Africa and America. When Somalia died, then Rwanda happened. The Sudan has always been on."

A herd of wildebeests scramble as a balloon comes in for a landing in the Masai Mara (above), part of the Kenyan national park system. Club member Christian Strebel tows a glider aloft with his Piper Pawnee PA-25 (right).



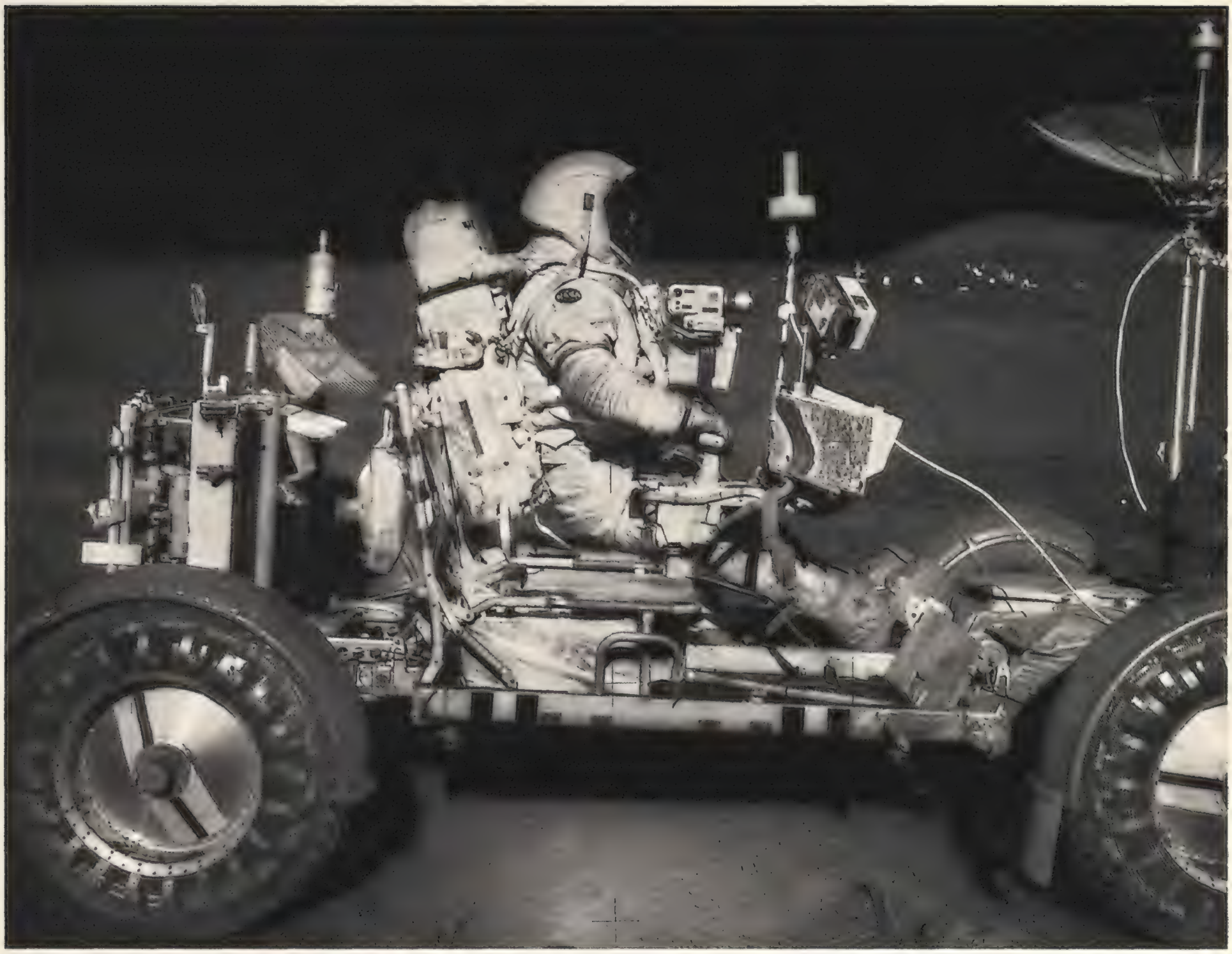
Fun is one measure of the club's success these days, and tonight there is plenty of it. Derek Rungren challenges Patrick Irwin's record of 11 seconds to down a yard of ale. "Come on, then," Irwin says as he removes his watch. Rungren tips his head, gulps beer, then stares at the trumpet-shaped glass. Barely one-sixth is gone. He is shocked.

In the background one pilot asks, "Have you had malaria?"

"Five times, how about you?" another answers.

Sinton, who was born in Kenya, looks around and says, "There is a name for the grown children of the original settlers—Kenya Cowboys, 'Strong in the arm, weak in the head.' They wear shorts regardless of the occasion or the weather."

Some nights at the club are like being with Peter Pan and the Lost Boys in Never-Neverland. But in a country where hyenas can eat you before help arrives, even the wildebeest occasionally kick up their heels.



SIGHTINGS

Apollo astronauts who labored for hours at a time on the lunar surface have a warning for scientists and engineers who might be contemplating a return to the moon: Beware the dust. The lunar surface is covered with a fine powder of sharp-edged impact particles accumulated over millions of years—and spared the polishing effects of erosion. The dust played havoc with tools and instruments and burrowed deep into spacesuit fabric.

But even the dust is beautiful in Michael Light's new book *Full Moon*, in which the San Francisco artist and photographer presents some of the most stunning images brought back from the moon. Light, who gained unprecedented access to original NASA transparencies, chose photographs—most never published before—that convey not only the serene beauty of the lunar landscape but also the type of work environment on Earth's natural satellite.

Low gravity made getting around a breeze. Walking was fun, but driving was a blast: Apollo 15 astronaut James Irwin photographed Commander David Scott as he test-drove the first lunar rover (above). The car weighed 462 pounds on Earth but only 77 on the moon, making for "a spirited ride," according to Light.

On the same mission, Irwin captured a dust-covered Scott as he manipulated collection tongs at Spur Crater (right), where the pair discovered the "Genesis Rock," a scientifically invaluable piece of the moon's primordial crust. It helped scientists estimate the moon's age, 4.5 billion years, and further understand its composition and history. It also helped everyone forget the hassle of a little bit of dirt.



If You Knew Harry

Skylark: The Life, Lies, and Inventions of Harry Atwood

by Howard Mansfield. University Press of New England, 1999. 238 pp., $28.00 (hardcover).



NASM

Pioneering aviator Harry Atwood makes a strange and at times maddening subject, but thanks to Howard Mansfield's intriguing biography it's hard to stop reading about him.

A bundle of contradictions, Atwood was known for his lacerating emotional cruelty toward his family, his utter unreliability and deviousness as a business partner, and his reckless spending habits. Atwood was described by those who knew him as a "sharper," a "con man," and "the worst kind of liar." He left a trail of ruined businesses behind him; nonetheless, he remains an interesting character.

He was a daring pilot who pushed his primitive aircraft to early distance records, and he deserves recognition as a visionary who predicted the future of aviation and space exploration with uncanny clarity—work stations that could orbit in space, in-air launches of small airplanes, huge flying wing designs, and a high-altitude weapons system that foreshadowed the later Star Wars concept; in the late 1930s Atwood declared, "We shall be journeying through interstellar space before the advent of another generation." And despite his total inability to work with others, Atwood invented a number of products that were important for the aviation industry: a lightweight plywood-plastic laminate for airplane fuselages, a rubberized product for wheels, woven metal fabric, and a silver-ionizing water purification system still used in modern spacecraft.

The best parts of *Skylark* are Mansfield's descriptions of early flight, "at once joyous and terrifying...only a few miles an hour separated the top speed from stall speed." In the first decade after the Wrights took wing, every flight was experimental, every pilot might set a record, but every pilot risked a grisly death. Early aircraft were ferociously difficult to control. Still, the lure of the skies proved irresistible to Atwood, who learned to fly in just a few hours. While stunt pilots were the glamour boys, Atwood grabbed headlines by flying for distance. In 1911 he shattered old records by flying 135 miles to watch the Harvard-Yale crew race. In that year, he also demonstrated a Wright Model B on the South Lawn of the White House (above). Other challenging flights followed.

Atwood was a peerless self-promoter who soon mesmerized the press. Breathless coverage in turn led to a number of aviation-related business propositions, and there followed decades of heartache for investors, civic leaders, and Atwood himself. The author does convey, amid this wreckage, the flashes of genius that led to Atwood's many inventions. Unable to get the military to work with him in his later years, Atwood eventually served time for theft and died in 1967 at his Ozarks homestead.

—Nan Chase wrote "One Helluva Roar" for the April/May 1999 issue.

CANADIAN WINGS

Otter and Twin Otter: The Universal Airplanes

by Sean Rossiter. Douglas & McIntyre (distributed by Classic Motorbooks), 1998. 202 pp., $34.95 (hardcover).



Sean Rossiter covers the development of some of the most rugged aircraft ever flown—and landed on wheels, skis, and floats around the world. *Otter* is the follow-on to *The Immortal Beaver,* published in 1996 (also distributed by Classic Motorbooks).

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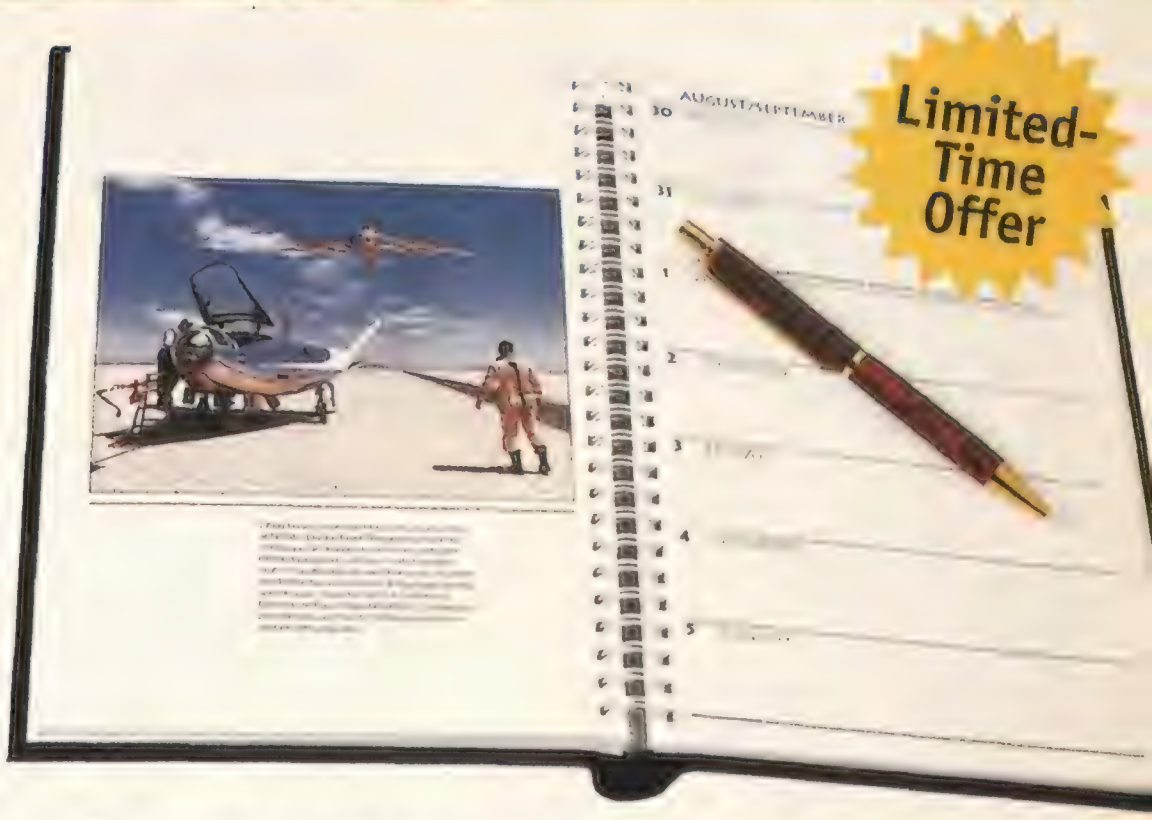
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FLIGHT Simulator 2000 by Microsoft, $59.99; Flight Simulator 2000 Professional Edition by Micosoft, $99.99. (425) 882-8080, www.microsoft.com/games/fsim.



Due out this fall, *Flight Simulator 2000* represents the latest installment in the legendary 17-year-old series. The new version will add a number of refinements, including 16-bit color 3-D scenery. Approximately 40 cities will be modeled in 3-D, with six major cities rendered in high resolution.

Two new passenger aircraft—the Boeing 777-300 and the Concorde—have been added to the mix of aircraft, all of which will sport updated instrument panels, virtual cockpits, detailed exteriors, and enhanced sound effects, as well as Global Positioning System navigation.

FS 2000 will also contain more than 20,000 airports around the world and is reportedly the only general aviation simulation to tap the Jeppesen database of real aviation charts. In addition, *FS 2000* will also be able to use real-time weather information from the Internet. And unlike *Flight Simulator 98*, both *Flight Simulator 2000* and the more comprehensive *Flight Simulator 2000 Professional Edition* will include a paper manual, so players won't have to go on line to read the instructions.

Pro Pilot 2000 by Sierra, $49.99, (425) 649-9800, www.sierra.com.



Pro Pilot 2000 is the fourth installment in Sierra's high-flying *Pro Pilot* series and looks to be its best effort yet. Like its predecessors, *Pro Pilot 2000* will encompass Western Europe, the United States, and parts of Canada, and feature an enhanced Hawaiian Islands scenery set that has to be seen to be believed. The improved terrain engine will again employ a 3-D topographical model based on 38 million elevation points taken from U.S. Geological Survey data. The Year 2000 update will also boast two types of Global Positioning Systems and offer 800-by-600 resolution for larger and more detailed instrument panels. Word has it that the developers have created a new air traffic control system that will provide radar vectoring through the terminal and en-route environment.

Like *Pro Pilot 99*, *Pro Pilot 2000* will incorporate an online handbook that contains 48 in-depth tutorials and other aids, which was developed in cooperation with the National Association of Flight Instructors.

Fly! by Gathering of Developers, $49.99. (800) GOD-GAME (463-4263), www.godgames.com.



Developed by Terminal Reality and published by Gathering of Developers, *Fly!* is one of the most advanced and realistic general aviation simulations available for your PC.

Each of the five aircraft features an exquisitely rendered interior and a fully functional instrument panel. However, the glide slope needle on each of the aircraft seemed improperly modeled. In an actual aircraft, a low needle during an Instrument Landing System approach means you're flying too high and need to reduce power. In *Fly!*, however, a low glide slope needle during approach indicates you're coming in too low, so forward pressure on the yoke causes you to crash.

Players can modify any of the environmental conditions and can even adjust some of the other realism settings, including the level of traction on the runway. Best of all, players can log on to the Internet and import real-time weather data, then fly through the same weather conditions.

Because *Fly!* is such a processor-intensive program, players will need at least a Pentium III computer, equipped with 128-MB RAM and a third generation graphics accelerator card, to get it to run well.

Flight Unlimited III by Looking Glass Studios, $49.99. (617) 441-6333, www.lglass.com.



Although *FU III* is set only in the Seattle area, the high-fidelity terrain engine is sharper and far more detailed than those found in either *Pro Pilot 2000* or *Flight Simulator 2000*. More than 10,000 square miles of photo-realistic terrain have been modeled—with resolution down to four meters per pixel. *FU III* also works in conjunction with the earlier *FU II*, so players can take a virtual voyage from Seattle down the West Coast to the streets of San Francisco.

FU III features one of the most advanced real-time weather generation systems available today, and even incorporates such things as humidity and phases of the moon into its calculations.

Ten aircraft are modeled from the inside out, from a Fokker Triplane to a P-51D. Although its scope is still somewhat limited, *FU III* is nevertheless one of the more impressive general aviation simulations.

—Marc Dultz is a freelance software reviewer who lives in New York.

Into The Tiger's Jaw: America's First Black Marine Aviator

by Lieutenant General Frank E. Petersen with J. Alfred Phelps. Presidio Press, 1998. 416 pp., $24.95 (hardcover).



Into The Tiger's Jaw is more than the autobiography of Frank Petersen (see "An Eagle's Wings," June/July 1988), a man driven by ambition who sacrificed two marriages and families to his dreams—it is also a personal history of race relations within the United States Marine Corps in the last half of the 20th century.

Petersen joined the corps in 1950—when few blacks were admitted—and rose to its highest levels. His secret was simple: Do it better than anyone else so they can't deny you. Whether Petersen, who had become the corps' first black aviator, was leading a wing of F-4 Phantoms into battle, fighting morale and race problems in the armed services, or running the Marines' largest education and training facility at Quantico, Virginia, he excelled. But from Petersen's first day in the corps—when a recruiter praised his high entrance scores but encouraged him to be a steward—to his last, he found race to be the central issue of his career. He candidly recounts the toll such pressures, as well as the challenges of his military life, took on his family. Petersen reveals how his profession often made him a chronically absentee father, brother, and husband.

ON PBS: NOVA TAKES OFF

"Time Travel," Premieres October 12, 1999, 9:00 p.m. EST

Examines wormholes, black holes, and the theories of physicists who believe time travel may be possible someday.

"Top Gun Over Moscow," October 19, 1999, 9:00 p.m. EST

The U.S. Navy Blue Angels and the Russian Knights compare skills, stories, and aircraft.

"Faster than Sound," November 16, 1999, 9:00 p.m. EST

Reveals previously unknown details about the quest for Mach 1.

ROCKETS ON YOUR DISK DRIVE

Space Transportation: Past, Present, & Future.



NASA Marshall Space Flight Center (www.msfc.nasa.gov), CD ROM, 1998.

A compilation of archival footage and virtual reality models of Robert Goddard's rockets to the X-33 VentureStar, one of the latest concepts in reusable space vehicles.

Petersen served in Korea and did two tours in Vietnam, where he was awarded a Purple Heart for injuries received when his F-4 was shot down by ground fire. Among his other challenges was serving on a Department of Defense team investigating racial concerns in the early 1970s, when race riots were fresh memories at home. The climate was no less tense within all branches of the U.S. military. Petersen's fact-finding investigations through racially turbulent Army units stationed in Germany makes for compelling reading.

Tiger's Jaw is an inspiring account by one of the men who helped make full racial integration of the armed forces not just an edict but a reality.
—Mark McKellar is a freelance book reviewer.

Never in Anger

by Anthony "Bugs" Bendell, Orion (call 011-44-1285-713456 to order), 1998. 333 pp., b&w photos, $28.60 (hardcover).



As the title proclaims, the author saw no combat during his career with the Royal Air Force, so this memoir is valuable mainly as a description of military life in peacetime. For students of the era when all air arms were making the transition to jets, Bendell does a competent job of documenting the obstacles. It takes patience, though, to hack through an extensive undergrowth of personal detail. Most touching: the parts where Bendell deals with tragedy, including his being afflicted with multiple sclerosis, which ended his career.
—George Larson is the editor of Air & Space/Smithsonian.



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3) Each entry must be postmarked no later than the last day of the month on the issue cover and received by the 10th of the month following the issue date. Mail entries to: Air & Space/Smithsonian Magazine Contest, 901 D Street SW, 10th Floor, Washington DC 20024.

4) Six contests: (1) December 1998-January 1999, (2) February-March, (3) April-May, (4) June-July, (5) August-September, (6) October-November 1999 issues.

5) One winner will be randomly selected from all correctly answered entries from each of the six contests by Marden-Kane, Inc. an independent judging organization whose decision in all matters relating to the rules and administration of the contest is final and binding. Each of the six contests' winners will be awarded a Garmin 111 Handheld Satellite Navigator, approximate retail value $350.00 each.

6) SECOND CHANCE GRAND PRIZE DRAWING. In addition to the prize awards for the six contests, a "second chance" random Grand Prize drawing will take place on December 10, 1999. All eligible entries from all six contests will be automatically entered in the Grand Prize drawing. The prize...a $2,000 voucher for flight training provided by G. A. Team partner flight training facility. Winner will be provided with a list of facility locations. Transportation to and from the facility not included. Total A.R.V. of prizes $4,100.00.

7) Winners will be notified by mail. All entries become the property of Air & Space and none will be acknowledged or returned. Contest open to legal residents of the U.S. and Canada 18 years of age or older at time of entry. Void in Quebec and Puerto Rico and wherever prohibited. Employees of Smithsonian Institution, advertising and promotional agencies, contributors to Air & Space and their families not eligible. Canadian winners will be required to answer an arithmetical skill question administered by mail.

8) Odds of winning each contest dependent on the number of correct entries. Taxes, if any, are the sole responsibility of the prize winner. All Federal, State, local and provincial laws apply.

9) Sponsor not responsible for damage, losses or injury resulting from the use and acceptance of a prize. Winners consent to use of name and/or likeness for editorials, advertising and promotion purposes without further compensation, except where prohibited by law. No substitution or transfer of prize permitted.

10) For a complete winner's list, available after December 10, 1999, send a stamped, self-addressed envelope to Air & Space "Unidentified Flying Object" Contest Winners, 901 D Street SW, 10th Floor, Washington DC 20024

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CREDITS

Ninety Minutes. Kalpana Chawla is an astronaut by profession and an aerospace engineer by education. She enjoys exploring the country in light airplanes.

Breakfast of Champions. Joshua Stoff is the air and space curator at the Cradle of Aviation Museum in Garden City, New York, which will open in 2000.

The Spirit of Knob Noster. James R. Chiles is a freelance writer who lives in Minnesota. He wrote about the manufacture of Cessna light airplanes for the Oct./Nov. 1998 issue of *Air & Space/Smithsonian.*

Mark Godfrey is a full-time photographer and part-time pilot holding a commercial license with a glider rating. His passengers frequently get the jitters when they see him simultaneously taking pictures and flying the airplane.

The Art of the Chart. Stephan Wilkinson, a mapaholic, has been fascinated by cartography since the days when he pored over charts in the wheelhouse of freighters as a young merchant seaman. As the automotive editor of *Condé Nast Traveler,* he frequently resorts to out-of-date road maps to avoid the indignity of having to stop and ask for directions.

The One-Pound Problem. Contributing editor Tony Reichhardt last wrote for the magazine about missile testing on Kwajalein Island (Dec. 1997/Jan. 1998). He lives in Fredericksburg, Virginia.

Illustrator Paul DiMare did not have the math skills necessary to work for the space program so he joyfully settled for painting the stuff.

Working for the Wright Brothers. Aeronautical engineer Quentin Wald has been studying and writing about early aeronautical history and taking part in the analysis and replication of early Wright aircraft.

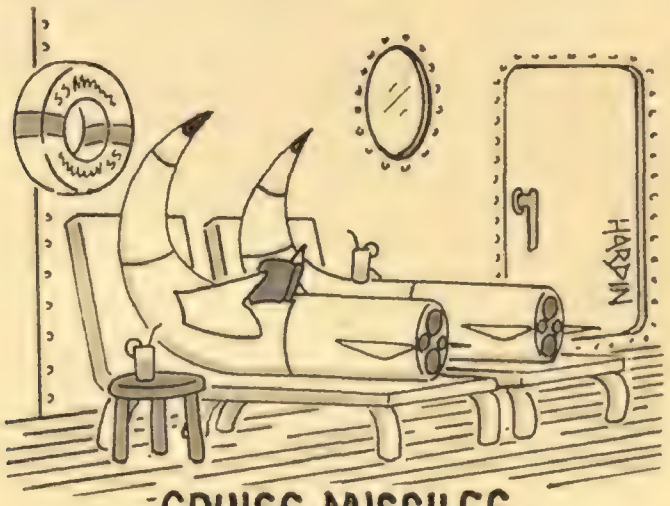
Breaking the Sonde Barrier. Tad McGeer, Insitu's president and chairman, trained as an aeronautical engineer. In the 1980s he moved into academic research on walking robots, and in 1990 he merged his robotic and aeronautical interests for initial studies of unmanned research aircraft as chief scientist at Aurora Flight Sciences.

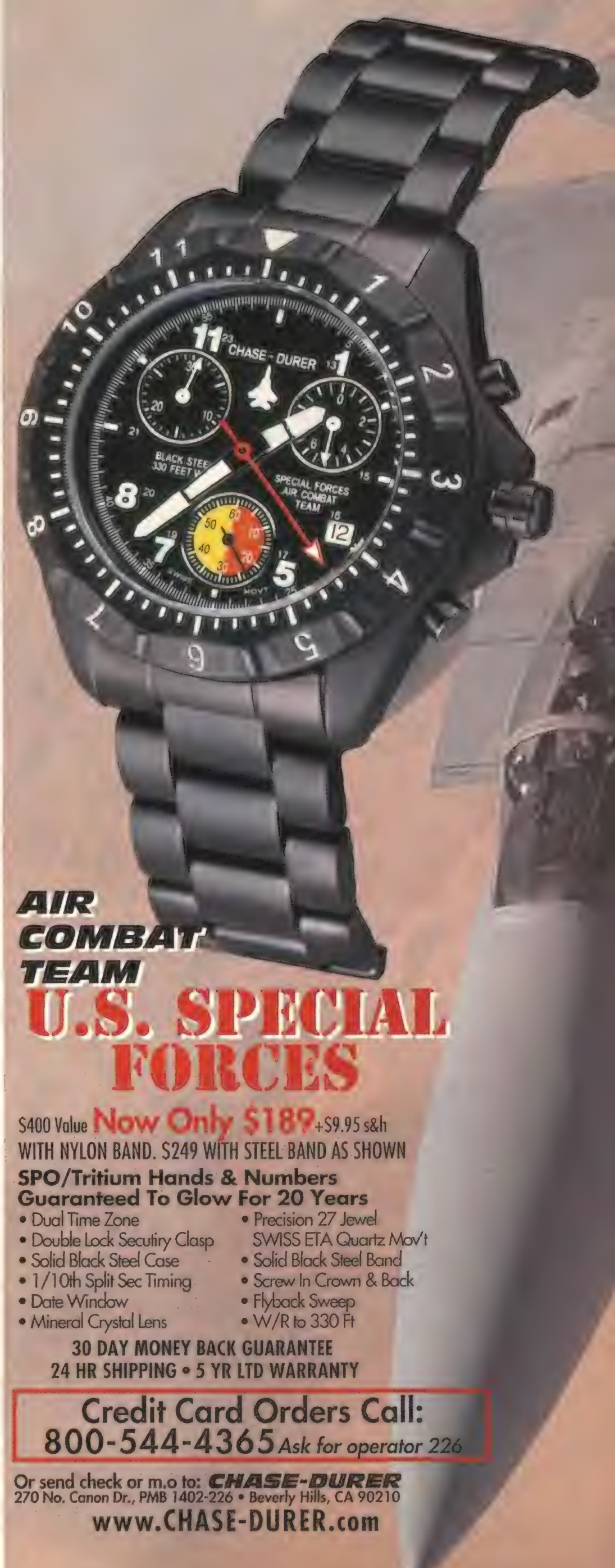
Rehab for Rockets. Preston Lerner wrote "Lifeboat," a story about the space station's crew-rescue vehicle, for the Aug./Sept. 1998 issue.

The Legends Club. Debbie Gary Callier has been an airshow pilot in North America since 1971 and hopes to fly her first airshow in Africa next year. She has contributed to *Flying* and *Air Progress.*

Tim Wright loves to get photography assignments that take him up in the air, in any kind of airplane.

Above It All. Frequent Collections contributor Richard Sassaman lives in Bar Harbor, Maine.





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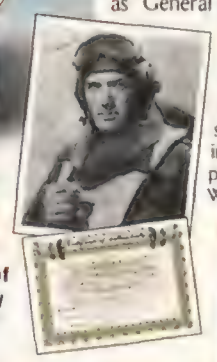
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CALENDAR

October 2
EAA Chapter 690 Fall Classic AirFair. Lawrenceville, GA, (770) 339-0804.

October 7–10
Aviation Expo China '99. China International Exhibition Center, Beijing, People's Republic of China, phone (Hong Kong) 852-25117427.

October 16
Bellanca-Champion Club East Coast Fly-In. Reading Municipal Airport, Reading, PA, (518) 731-6800.

October 16 & 17
Open Cockpit Weekend. New England Air Museum, Bradley International Airport, Windsor Locks, CT, (860) 623-3305.

October 19–21
World Aviation Congress. Society of Aerospace Engineers. Hyatt Regency San Francisco Airport, San Francisco, CA, (703) 264-7500, www.aiaa.org.

October 22–24
Florida International Jet Rally—The Finest in Radio Control Jet Aircraft. Lake Wales Airport, Lake Wales, FL, (941) 667-1785, e-mail: fjfjets@aol.com.

November 2–4
International Space Business Assembly. Sponsored by the United States Space Foundation and the American Astronautical Society. Reagan International Trade Center, Washington, D.C., (703) 866-0020.

November 3–5
NASA Johnson Space Center's Inspection '99. This event, for industry, business, and education professionals, offers a look at how NASA has developed technologies that have down-to-Earth applications. Johnson Space Center, Houston, TX, (281) 483-2462.

November 6
EAA Chapter 690 Fly-In Pancake Breakfast. Lawrenceville, GA, (770) 613-9501.

November 16–18
American Astronautical Society Annual Meeting and Conference. Pasadena Hilton Hotel, Pasadena, CA, (703) 866-0020, e-mail: aas@astronautical.org.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *901 D St. SW, 10th Floor, Washington DC 20024; fax (202) 287-3163. Events will be listed as space allows.*

FORECAST

In the Wings...



TIM WRIGHT

All Together Now!

In the most dazzling of airshow performances, military precision aerobatic teams fly in formation with only inches between wingtips. But can mere mortals do it? They go to Vernon Ricks' formation flying school in Greenwood, Mississippi, to learn how.

Marsplane

Aerial photography might be a cinch on Earth, but what kind of craft can skim the surface in the ultra-thin atmosphere on Mars?

Life Saving

Acquiring every item pilots have used to survive—helmets, oxygen masks, ejection seats, life rafts—has become the life goal of collectors on the extreme edge of what some call a hobby.

The Last Sniffer

One Congressional hearing away from the boneyard, the Air Force's TC-135 was hastily put back in service last year when India and Pakistan began rattling nuclear sabres. Equipped with sensors that detect traces of nuclear blasts, the aircraft still has work to do.

ON THE WEB SITE



BILL INGALLS/NASA

At the Kennedy Space Center, NASA Administrator Dan Goldin, astronaut Robert Cabana, and the Clintons watched the ascent of STS-95 with John Glenn aboard.

Inside Orbit

Air & Space/Smithsonian's Spacebeat now features veteran space reporter Beth Dickey with the inside scoop on doings and decisions at NASA's space centers. Could you hire the space shuttle for a salvage mission? Dickey reports on United Space Alliance's first tentative steps toward "reimbursable flights" as she keeps her eyes on the astronauts, cosmonauts, and policy wonks involved in the U.S. space program. For continuing updates on space shuttle missions, progress reports on the international space station, and now Dickey's "Inside Orbit," visit www.airspacemag.com/asm/web/spacebeat.html.



USAF

Inner Spirit

Just a reminder: You can take a QuickTime VR tour of the B-2 Spirit's cockpit at www.airspacemag.com/asm/web/site/QTVR/B2.html. Look closely. There's a spirit in the Spirit.

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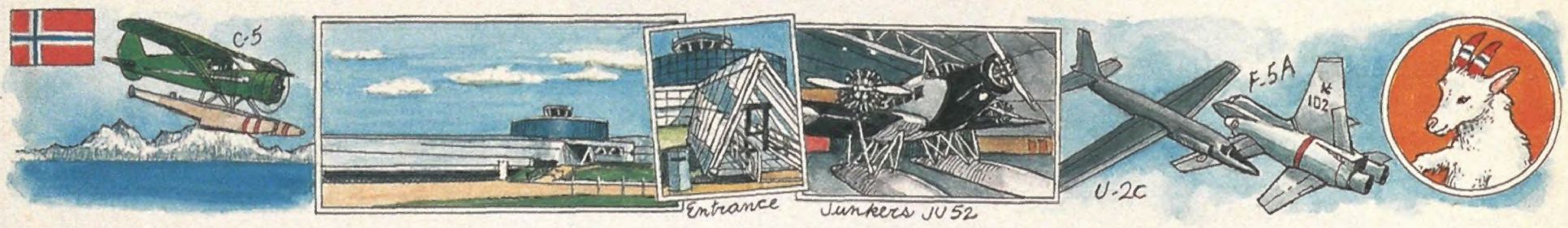
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JOHN HEINLY

Above It All

Who'd guess there was a world-class aviation museum above the Arctic Circle? Five years ago, the Norsk Luftfartsmuseum (Norwegian Aviation Museum) opened in the town of Bodø. The building is shaped like a gigantic propeller, with military exhibits on the left blade, civilian on the right.

The museum's three dozen airplanes span decades of aviation history. There's an Avro 504K, a fighter-bomber-reconnaissance craft that Norway's army used from 1917 to 1930; a World War II Hawker Hurricane; and such cold warriors as a U-2C, an F-84G Thunderjet, and an F-5A Freedom Fighter. The latter three were sent from the United States to its NATO partner.

Exhibits are laid out with style. A World War II Junkers Ju 52/3m, displayed with floats, spreads its 96-foot wings in front of an island wharf. Viewers watching a movie about Scandinavia's major airline, SAS, sit in the seats of a cutaway fuselage. The exhibit area documenting Little Norway, a camp that the Norwegians used for flight training during World War II in Muskoka, Ontario, includes a two-story log cabin and stuffed examples of the airmen's three mascots: a dog, a black bear, and a goat with horns painted Norway's red, white, and blue.

Enter the civilian side and you'll find 12 clear plastic suitcases rotating on a baggage carousel. Each contains a small display with a pertinent statistic—"Every day, [an average of] 51,024 passengers arrive at, or depart from, Norwegian airports," reads one; another says: "During winters with heavy snow, around 55,000 truck loads of snow are removed from Norwegian airports."

One exhibit documents Scandinavians who made pioneering flights: Roald Amundsen, who in 1926, accompanied by Umberto Nobile, made the first flight over the North Pole; Ingrid Pedersen, the first woman to do so; Bernt Balchen, who paired up with Richard Byrd to make the first transatlantic crossing in a passenger airplane. Arctic aircraft on display include a late-1940s Honningstad C5 Polar floatplane. Used for ambulance and taxi service along the fjords, the Norwegian-built C5 carried two pilots and either five passengers or two stretchers.

In the 1930s, gliding and aero clubs became popular in Norway, and at one end of the civilian wing hang three gliders, the oldest a 1930s single-seat Grunau 9 built in Germany. It looks something like a flying sled. The FES 530 Lehrmaster and red-tail L-13 Blanik are similar two-seaters from the mid-1950s, with wingspans of about 55 feet. The former is wood and fabric; the latter, from Czechoslovakia, is metal.

Norsk Luftfartsmuseum, Olav V Gate, P.O. Box 1124, N-8001 Bodø, Norway. Phone 47 75 50 78 50; e-mail: flymuseum@luftfart.no; Web site: www.aviation-museum.com. Hours, late May–late Aug.: Sun.–Fri., 10 a.m.–8 p.m.; Sat., 10 a.m.–5 p.m. Rest of the year: Mon.–Fri., 10 a.m.–4 p.m.; Sat. and Sun., 11 a.m.–5 p.m. Admission fee depends on age.

Mannequins are used well throughout the museum. Far overhead, a row of six in flightsuits are posed in ejection seats. Two in uniform link hands as one prepares to spin the propeller of a 1920s trainer, the Kjeller FF9 Kaje I. Another, with flippers, descends from a Bell 47-D rescue helicopter to save one hanging onto a life raft.

American visitors can figure out the museum's displays easily. For one thing, almost everyone in Norway speaks English. (On a recent visit, one Norwegian murmured, "Beautiful, just beautiful," as he ran his hand over the museum's de Havilland DH 98 Mosquito. "Look at the shape of that wing. Now *that's* sexy.") In addition, most displays are captioned in Norwegian, English, and German, and those signs without English translation can usually be figured out, such as the one pointing up the stairs to the *Kontrolltårn*. For 30 years, the octagonal control tower, on top of the museum, ran Bodø's airport; in an emergency it could do so again. The tower offers visitors a stunning view of the surrounding islands and mountains.

The town of Bodø itself is not all that beautiful—"We are not an architectural pearl," one resident admits—but it has a good excuse. In 1940 it was bombed flat by the Germans. Only two buildings were left standing in its 46-block downtown.

Bodø *can* boast about its aviation history. For one thing, the town is the answer to a great cold war trivia question: Where was Francis Gary Powers going when his U-2 reconnaissance craft was shot down over Sverdlovsk in the Soviet Union in 1960? Initially, "the Norwegian government denied knowing anything about this operation," a sign at the museum says. The truth was that Powers was flying to Bodø to turn the airplane over to fellow U-2 pilot Marty Knutson. Last June, Knutson and four other pilots who flew U-2s for the CIA in the early days of the program reunited during a conference that the museum sponsored for NATO's 50th anniversary.

At the start of the cold war, NATO made Bodø its front line of defense against a Soviet attack. The town was well positioned for the role: Flight distances between the superpowers are shortest over the Arctic circle, and missile trajectories that the Soviets plotted from Russia to the United States pass directly over Bodø. In addition, the Soviets built the world's largest naval base on the nearby Kola Peninsula. In response to all this, NATO set up many military bases in the area, established a communications-radar network with early-warning systems, and installed listening and sounding devices along the northern Norwegian coast.

"The front was up in the mountains," says the museum's Karl Kleve, describing NATO's defense infrastructure. "Down here in Bodø, we sat and steered it all."

—Richard Sassaman

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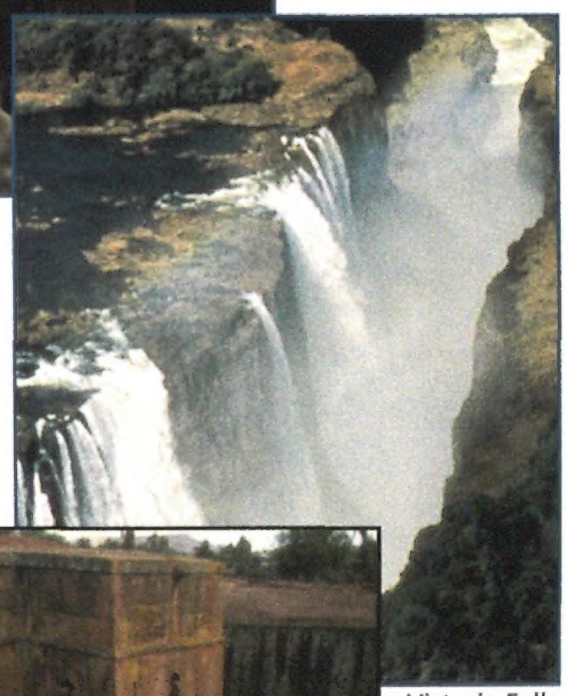


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Victoria Falls.

For the aircraft enthusiast, a special treat will be touring the Swartkops Airforce Museum and flying aboard the historic DC–3 "Delaney." This aircraft served in the United States Army Airforce, the Royal Canadian Airforce Squadron in the United Kingdom, and towed gliders during the Rhine crossing in 1945. The DC–3 has been painstakingly restored to her present immaculate condition. Join Smithsonian Study Tours for the experience of a lifetime and a classic flying adventure across Africa.


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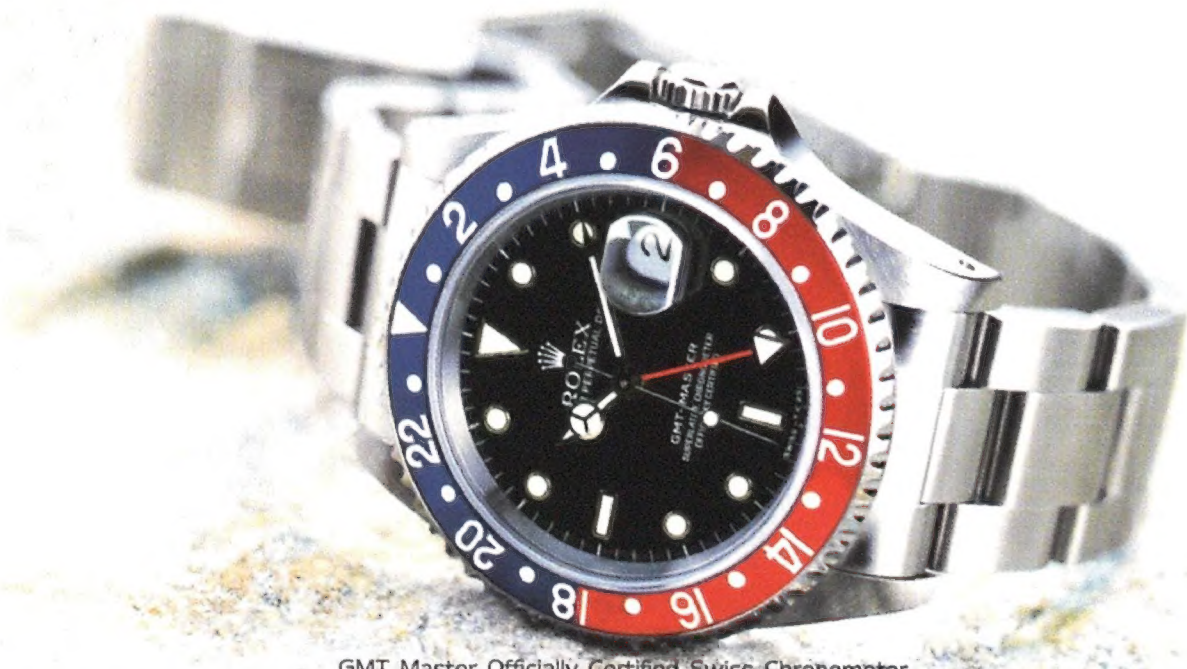
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